INDIAN TEA ASSOCIATION.

TOCKLAI EXPERIMENTAL STATION

PROCEEDINGS

OF THE

SECOND ANNUAL CONFERENCE.

Held at Tocklai on the 17th, 18th and 19th February, 1938.

MEMBERS ATTENDING THE CONFERENCE.

Chairman.	Mr. P. H. Carpenter—Chief Scientific Officer.	
Delegates.	Mr. E. J. Nicholls—Indian Tea Association, Calcutta.	
	Mr. D. H. Mackay—Indian Tea Association, Calcutta.	
	Mr. R. L. McLennan— Mr. R. G. Boyle—	Assam Branch Indian Tea Association, South Bank.
	Mr. M. H. Burton—	Assam Branch Indian Tea Association, North Bank.
	Mr. J. W. Smart— Mr. W. Cullen—	Surma Valley Branch Indian Tea Association.
	Mr. F. M. Graham— . Mr. T. W. Allan—	Dooars Planters' Association.
	Mr. K. I. M. Fegan—Darjeeling Planters' Association.	

Mr. H. R. Cooper—First Chemist, Tocklai Experimental Station.

Mr. A. C. Tunstall—Mycologist, "

Mr. C. J. Harrison—Second Chemist, "

Mr. S. F. Benton—Bacteriologist, "

Dr. W. Wight—Botanist, "

Dr. E. A. H. Roberts—Third Chemist, "

CONTENTS.

2-30 p.m. each day—Visits to Laboratories and Field Experimental Plots.

PROCEEDINGS OF A MEETING HELD ON THURSDAY 17TH FEBRUARY, 1938, AT 9-0 A. M. AT THE TOCKLAI EXPERIMENTAL STATION.

The Chairman, in opening the Conference, welcomed the delegates to Tocklai and outlined the programme and arrangements for its 3-day session.

Mr. E. J. Nicholls then addressed the meeting and after expressing his pleasure at being able to attend, said that on behalf of Mr. C. K. Nicholl (Chairman, Indian Tea Association, Calcutta) he wished to express the latter's regret at inability to be present as he was in Delhi in connection with the Tea Restriction Act.

REPORT ON THE WORK OF THE DEPARTMENT DURING 1937.

The Chairman then gave the following report on the work of the Department during 1937.

"Messrs. Cooper and Tunstall were on home leave for periods of seven and four months respectively. No addition to our senior staff took place until November and under the circumstances it was impossible to undertake any touring beyond that necessitated for attending the various Annual General Meetings of the Assam Valley and Surma Valley Branches of the Indian Tea Association, the Dooars Planters' Association, the Terai Planters' Association, the Darjeeling Planters' Association, and the Indian Tea Association, Calcutta. These meetings were attended in accordance with the usual custom.

I now will discuss the experimental work in the same order to which it is referred in the 1937 Programme of Work.

In previous years we made experiments to find out the effect that varying degrees of fineness of plucking had upon the quality of the tea made. In general the finer the leaf plucked the better was the quality, although the differences were small between superfine plucking consisting chiefly of one leaf and a bud, and fine plucking to medium plucking consisting entirely of 2 leaves and a bud. The different pluckings were all taken over 8″ of new growth and then to the janum. A further obvious experiment is to alter the initial lengths of growth. An experiment in this direction was made throughout the year and is an extension of work started in 1935.

The season's manufacture was divided into three parts—

(1) the late second flush—4th June to 30th July
(2) the rains period —6th August to 24th September
(3) the autumnal period—1st October to 31st November.

Leaf was manufactured from bushes tipped at different heights from the pruning level, in some cases plucked subsequently to the janum throughout the season, and in others, over a big leaf on the second round only.

Owing to the climatic conditions it was impossible to obtain sufficient leaf for manufacture before the end of June and consequently no comparisons could be made of early second flush teas.

On the late second flush teas there is no significant difference between any of the valuations for the teas from the different forms of plucking nor is there any difference in regard to tip, colour of infused leaf, liquor, strength, quality, and briskness. In the late second flush therefore, the form of plucking giving the greatest crop has given the best return.

During the rains period the Calcutta tasters find that the leaf plucked over a serrated leaf at the second round only of plucking gave better tea than plucking over 4″ and 6″ of new growth to the janum but there is no significant difference in the case of the 8″ length. The London tasters show no significant differences but their order of merit confirms the Calcutta tasters' opinion. The Calcutta tasters indicate slightly better quality of liquor in the rains tea from bushes plucked over a leaf in the second round of plucking compared with bushes plucked throughout to the janum. There are no indications of any differences due to the different initial lengths of growth.

In the autumnal period both the Calcutta and the London tasters show a significant preference for teas plucked over a serrated leaf on the second round of plucking compared with teas plucked throughout to the janum. In this period also, the longer the initial growth the better were the teas. Furthermore, an improvement in quality is noticed and also in tip, colour of infusions, liquor, and briskness. The Calcutta tasters showed a preference for the autumnal tea made

from bushes plucked to a short length of 4″ of new growth and then to the janum up to August and then the plucking height raised by 2 serrated leaves at the centre of the plucking surface, compared with all other forms of plucking except 8″ of new growth and a serrated leaf at the second round of plucking.

The tea in the experiment to which I have just referred was pruned in December. The pruning of a garden must, however, extend over a considerable period of time and consequently it is of importance to know whether top pruning at different times of the year has any effect upon not only the crop but also the quality of the tea made. The results of an experiment carried out during the year are as follows.

The pruning was done during six different months so that we have teas made from bushes pruned more than 12 months previously and bushes pruned less than 12 months previously.

During the early part of the year in the time of the early second flush, owing to the climatic conditions to which I have already referred, we were unable to manufacture the tea from December or later pruning; but the leaf from bushes pruned in the previous April, June and October was manufactured from the 18th May to 15th June. Both the London and Calcutta tasters preferred the tea from the October pruning. This preference was greatest at the first manufacture and the difference became less by the middle of June.

From the 22nd June until the 16th November all the different pruning treatments were manufactured. Pruning in December and January has given over the whole period the best results. Tea pruned before that time has given poorer results and tea pruned at a later date (in February) also has given slightly poorer results. The differences for the cold weather pruning are small and it would seem from this first experiment that pruning at any time during the cold weather between October and February makes little difference to the quality of the tea made for any particular date of manufacture or on the average throughout the season. This is of importance as it permits of distributing the pruning over a longer period of time. In a previous year it was found that tea made from leaf plucked off bushes more than 12 months from pruning was not as good as tea

from leaf plucked off bushes less than 12 months from pruning, when the pruning was done in December. The present data support the previous findings. A further comparison was made between the tea cut across and that cleaned out, in the case of the previous April and the last December pruned tea. In both cases the cleaned out teas were the better. This was more marked in the case of the December pruned tea. These results are for the first time of carrying out this experiment and it will of course be necessary to replicate it in other years.

In the case of the teas made in connection with the two experiments to which I have referred, a difference was noticed in the amount of "creaming" of the liquors and an estimation was made of these differences. It was found that tea from clean-pruned bushes creams down more than tea from bushes annually cut across. It will be noticed that this corresponds with the better valuation but it is not suggested that the creaming down has been the cause of the increased value. It is however of interest to note that in this case it is coincident with it. It was also noticed that the shorter the initial growth left on the bush before tipping the greater is the creaming down of the teas made, and also that tea from bushes plucked to the janum give liquors which cream down better than tea from leaf plucked over one big leaf at the second round of plucking. This applies to late second flush teas and those made during the rains period. It was also noticed in the "time of pruning" experiment that for the same day of manufacture the teas from bushes longer from the time of pruning creamed down more. In the case of these experiments all the teas creamed well and it has not been possible to associate the degree of creaming with an improved valuation.

At the present time with the Restriction Scheme in force and gardens able to make their alloted crop quota easily, it is of some importance to know whether there is any advantage in pruning at any particular time of the year, and this year's experiments indicate that the pruning in the cold weather between the months of October and February does not make any marked difference in the quality of the teas made during the late second flush and the rains period. It was however hoped that we might have some information in regard to the comparative quality of the teas made during the earlier part of the year. Owing however to the peculiar climatic conditions this was not possible as only some of the pruning

treatments gave sufficient leaf for manufacture before the middle of June. So far then as this experiment allows tentative conclusions to be drawn, it seems that the October pruning has given teas not appreciably inferior to the teas pruned in the following December and it has given increased crop of ½ md. per acre up to the end of the second flush. This suggests that there may be a possibility of increasing the amount of early teas without appreciably altering the quality. It would however be unwise to draw any definite conclusions from one year's experiments. It will be necessary to repeat this experiment in other years. It cannot be carried out again in 1938 because the pruning will not then be in a similar stage.

In 1936 a preliminary experiment was made with the manufacture of tea plucked from individual bushes. It was noticed that there was a considerable variation in the quality of the tea made. This investigation was to be expanded in 1937 by manufacturing the leaf from 200 bushes belonging to the same jat. Unfortunately the miniature C. T. C. machine that we had expected to receive in the early part of the year did not arrive and indeed has not yet arrived. We therefore had to devise some other method for manufacture. I am glad to say that we were able to find a fairly satisfactory hand-method which has made it possible to carry out the programme, and in addition, to manufacture tea from an additional 108 bushes; in all, then, tea has been manufactured from 308 different bushes during the year. The results very clearly show that the individual bushes belonging to a jat of tea noted for its evenness give teas varying greatly in characteristics. This investigation has been made with the object of using bushes having desirable characteristics, for establishment of clones.

In the experiments comparing teas of different jats it was noticed that the fermentation proceeded differently for the different jats, and it was decided to investigate this. During the year however we have been able to do no more than study technique. We have not yet found a satisfactory method for measuring differences in the fermentation of the different teas.

The tea industry has generally accepted that a cool temperature for fermentation is advisable but this was based on general experience without reliable data. In 1935 and 1936 experiments were carried out to ascertain whether temperature during fermention did influence the quality of the tea and this investigation

was enlarged during 1937. I am glad to say that although we have not had the miniature C. T. C. machine, we have been able to carry out a great deal of the work; but under conditions that unfortunately were not as good as they would have been if we had had the machine.

The leaf for the experiment had to be rolled in the ordinary manner. During one hour of rolling the leaf becomes heated to a greater or lesser degree. Fermentation at controlled temperature follows. The results clearly indicate the improved teas made with fermentation at the lowest temperature, that is 70°F., and the very rapid falling off in quality of the teas as the fermentation temperature rises to 100°F. This laboratory finding has received confirmation in the course of other experimental factory manufactures at Tocklai, as shown by the correlation existing between the temperatures in the factory during manufacture and the valuations and reports of the teas made. We have, however, not been able to ascertain whether the rise in temperature during rolling had much effect. It is posssible that if the tea could have been kept at the low temperatures during the whole time of manufacture even better teas would have been made. This requires investigation. We hope that by using the miniature C. T. C. machine we shall be able to eliminate the necessity for rolling the leaf for any length of time and consequently eliminate the rise in temperature that is associated with rolling.

The effect of temperature upon the different characters of the tea is of much interest; for instance, tea fermented at 70°F. maintained a very bright colour of liquor throughout all the manufacture, whereas tea manufactured at higher temperatures showed a falling off with the lengthening of the time of fermentation and also with the different dates of manufacture. Other characters such as quality also showed changes.

It will be necessary to enlarge still further the scope of this experiment. The rise in temperature during rolling must be avoided and we must also experiment with still lower temperatures.

The results up-to-date are of interest in providing data confirming the general opinion of the industry that fermenting rooms should be kept cool. So far as these experiments go they do indicate the desirability of keeping the temperature

as low as it is possible to do by the use of humidifying arrangements. The use of efficient mist chambers should enable a tea house, suitably constructed, to maintain a temperature between 80°F. and 82°F. in the rolling and fermenting rooms. Unfortunately many factories are so built that it is difficult to obtain these temperatures. Whilst these results are of interest and suggest some practical application, yet they cannot be accepted as providing any final conclusion. The investigation must be continued.

Cleanliness of the surface of the bed on which fermentation is done is an important matter, and the choice of suitable materials for the beds depends much upon the ease of cleaning. During the year it has been possible to carry out further experiments throughout 16 weeks from July to November, manufacturing teas made by fermentation on a clean cement floor and on a polished aluminium surface. In no instance did the tasters' reports or valuations show any significant difference in favour of either type of fermenting surface.

The survey of moulds in finished tea has been continued and further data accumulated. At present this investigation is almost entirely concerned with accumulating data. It will be some time before we have sufficient to permit of a discussion of the results.

In the 1937 Programme of Work reference was made to the infection of unhealed wounds by pathogenic organisms being responsible for the death of a large number of bushes. It is in this connection that we have an experiment in progress to find out conditions that affect the rate of healing of a newly made cut. Bitumen, mixed with kerosene so as to make it possible to apply with a stiff brush, appears to be the most satisfactory of the treatments we have tried. The length of new growth left before plucking influences the healing. In the second year healing was more nearly complete on bushes that were plucked at 12″ as compared with those plucked at 6″ of new growth. Leaving a bush unplucked did not show a greater healing than bushes plucked at 12″ of new wood. Plucking to the janum without breaking back over 6″ and 12″ of new growth shows an increased tendency to healing but this is not noticeable on longer lengths of growth. The results up-to-date suggest that whilst healing of cuts will not take place in one year, a longer length of growth is helpful; this however need not be unduly long; and in

some cases need not extend to much beyond 12″ if the subsequent plucking is done without breaking back. Not breaking back seems to be more important than leaving a leaf at the second round of plucking.

A lot of work remains to be done in this direction for we have not yet found a wound dressing which, applied at the time of cutting, will keep the wound free from disease organisms without further treatment, until the wound has healed.

For several years we have been carrying on an investigation dealing with the starch reserves in the roots of the tea bush. A large amount of data had been collected but the interpretation was only possible by statistical analysis which involves a great deal of work.

We were fortunate in being able to get the help of Mr. S. S. Bose of the Statistical Laboratory of the University of Calcutta who came here for two months.

The results show that the amount of starch steadily increases as the season advances from spring to winter. The rate of increase is however not the same for bushes receiving different treatments. In the case of the untreated bushes, a significant correlation of an inverse order is found between the starch and the yield. Meteorological factors were also considered ; the only significant correlation was a positive one between starch and the total hours of sunshine. The crop yield did not show this correlation but gave a positive correlation with the daily maximum temperature.

At the beginning of 1935 a development study (as defined by the Commission of Enquiry) was commenced dealing with the flowering of the tea bush. The flowers develop only at the janum axils. The mode of coming away into a flush period which is recognised for leaves also applies to flowers. Whilst a flower bud develops during one flush period, it is not until the bush starts the next flush period that the flowers open. There are two flowering periods of a tea bush—one from the middle of the third flush to the advent of the first flush of the succeeding season, and the other from the beginning of the second flush to the end of the same flush. The flowers which open from the middle of the third flush to the advent of the first flush of the succeeding season are generally from the first to third flush growths of the shoots. The flowers on the third flush janum axils open at about

the end of the fourth flush and the flowers on the fourth flush janum axils open during the winter growth period. This flowering is over before the shoots come away for the new first flush.

The name by which the tea plant has been known has varied frequently. The International Horticultural Conference held in Paris in 1932 has included tea in the genus Camellia and we shall therefore adopt this nomenclature for the future.

During 1937 we have been unable to initiate any new field experiments at Tocklai because we had not the necessary permission to plant out land that had not been previously under tea.

The various field experiments are still being continued at Tocklai and generally call for no special comment.

Some results have been obtained from the treatment of young tea, however, to which I should like to call attention. In the cold weather of 1935-36, tea one-year old from seed was planted out. At the time of lifting from the nursery the plants were cut to a height of 8″ from the ground. The manurial treatment was commenced in the spring of 1936 and has been continued. At the end of 1937 the tea was cut across at 18″ from the ground and the prunings weighed. This weight was taken to indicate the growth of the bushes. Manuring with 60 lbs. of nitrogen per acre in the form of sulphate of ammonia significantly depressed the growth of the plants. The plants manured with 20 lbs. of nitrogen per acre were noticeably better than those which had no application of nitrogen. It seems that for such young plants, too great an application of nitrogen can be given. I particularly call attention to this as I think there is sometimes a tendency to be over generous in the application of nitrogenous manures to young tea. I suggest that for tea as young as in this experiment the application might be limited to 40 lbs. of nitrogen per acre unless there is definite information showing that for any particular garden a heavier dose is suitable. The same experiment showed an improved growth by the use of potash. This is of interest because the application of potash for a number of years to mature tea has had very little effect at Borbhetta.

Another experiment with young tea was made to ascertain what would be the result of pruning at different times of the year. Three different heights were adopted namely,

(a) 0″ to 2″ from the ground,

(b) 8″ to 10″ from the ground,

(c) 16″ to 18″ form the ground.

The times of pruning were February and June. The number of deaths associated with the different times of pruning are as follows

Pruning height.	Times of pruning.	
	February.	June.
0″ to 2″	16%	26%
8″ to 10″	0·9%	2·7%
16″ to 18″	0·8%	1·4%

When discussing last year the Programme of Work for 1937 I said that we hoped to have the results from experiments with the use of vegetable compost. Six experiments are being carried out on estates and there are two at Tocklai. The results of the first year show a small crop increase in two cases, and in the remainder there is no significant effect from the use of compost. It is to be noted that the use of the unfermented vegetable matter has given a better result than has been obtained from the same quantity of material composted. It will, of course, be necessary to continue these experiments for some years in order to find out what may be the value of such manures when applied over a long period of time. I wish, however, to suggest that it would be wise for estates not to incur any great expenditure in the preparation and application of composts until further reliable data are obtained.

There are a number of field experiments that are being carried out on various tea estates to ascertain the value of nitrogen, phosphate, and potash in the form of mineral manures in the different districts. The indications of the first year of the

experiments are interesting in that they show that, on bheel soils, nitrogen has given no significant increase of yield. There are indications that the use of potash on such soils is of benefit.

This year for the first time we adopted a definite glossary of terms for tasting the experimental teas. The different characters that we wished to study were defined by the tasting terms in general use but each of these terms was then divided qualitatively so that it was possible to compare teas in regard to briskness or quality or other characteristics for which the tea was examined. This system of tasting was readily accepted by tea tasters both in Calcutta and London, and the results have been of great value, for it has enabled us to understand how the different characters may be influenced by treatment, and also to understand how these characters may influence the final decision of the taster as indicated by his valuation. I wish to express my thanks for the assistance we have received from the various tea brokers—5 in Calcutta and 8 in London—who have gratuitously tasted a large number of experimental teas. Without their help it would have been impossible to carry out these experiments. Recently we have received intimation that other tea brokers in London who have not been in the past in our team are willing to help us in the future, and during the coming year we hope to make use of the services of 11 tasters in London as well as 5 in Calcutta. This is a great gain, as it enables us to carry out more experiments; hitherto a limiting factor has been the number of teas that we have been able to send to any one taster in a week. The experimental teas call for very critical tasting; they have to be infused probably several times, and their examination does take a considerable amount of the taster's time. Our thanks are also due to the Jorehaut Tea Company Ltd. for permitting us to make use of their tea taster, Mr. R. Gilchrist, who not only tasted teas made in the ordinary course of experimental manufacture but, who, in addition, tasted for us all the teas made from individual bushes. It was only possible to send such teas to one taster since the amount manufactured at one plucking from one bush was so small as sometimes to allow of only one infusion.

During November and December three Lecture Courses were held consisting of 20 members at each Course. My suggestion to have two Senior Courses was adopted.

During the year we had two scientific visitors; Dr. Eng. S. J. Wellensick and Dr. F. R. Tubbs, Ph. D. (Lond.), D.I.C., A.R.C.S., F.L.S. from the Theo Proofstation, Java and the Tea Research Institute of Ceylon respectively, who were particularly welcome by reasons of their interest in the selection and vegetative propagation of tea. I consider that such interchange of visits between the tea experimental stations is for the general benefit of the industry and is to be encouraged.

It gave me very much pleasure to be able to welcome to Tocklai Sir John Russell (the Director of Rothamsted Experimental Station), and Lady Russell.

I have already referred to the visit of Mr. S. S. Bose to Tocklai. His visit was of great value as he was able to discuss with Officers the most suitable statistics to employ, and also was able give training in elementary computing to some of the Unqualified Assistants, so that the officers could be relieved of a great deal of routine calculation.

Since Mr. Bose's visit we have had four such computors kept fully occupied.

Two publications, one by Mr. Cooper dealing with nitrogen and its relationship to crop and quality of tea, and the second by Dr. Wight dealing with the flushing of the tea bush, are both very much overdue, but the manuscripts are expected to be in the hands of the printers very shortly."

DISCUSSION.

The Chairman mentioned that Mr. Graham had brought with him from the Dooars several specimens of bark-eating caterpillar. These had been sent to the Entomological Branch where they would be open for inspection by the delegates.

Mr. Nicholls, referring to the Chairman's report of the work of the Department in 1937, asked why the C. T. C. machine had been singled out for use by the Scientific Department in its experiments on manufacture.

The Chairman explained that it was considered that the machine, as ordered, would prove particularly suitable for manufacture of leaf from individual bushes since it was possible to use it for manufacturing the very small quantities of leaf, obtained.

In a discussion in which the Chairman, Messrs. Graham, Cooper and McLennan took part, possible methods of manufacturing small quantities of leaf were referred to.

The Chairman said that hand-rolling had been successfully employed but it was a makeshift and there was considerable risk of taint occurring in the teas made by this method.

Mr. McLennan asked whether it would be possible for scientists visiting Tocklai and the North East Indian tea districts from other parts, to address planters in their different districts.

The Chairman said that he would bear this in mind for future occasions.

A discussion took place in which the Chairman, Messrs. Graham, Cooper Fegan, Nicholls, Allan, Tunstall and Harrison took part, on a question raised by Mr. Graham as to whether the Department had any theories to account for the disappearance of the autumnal flavour in the Dooars in recent years.

The Chairman thought that the tendency to closer plucking practised in recent years might account for a decrease in flavour and quality of teas made towards the end of the season.

Mr. Graham asked whether there was any connection between the 5-year Regulation Scheme and the disappearance of autumnal flavour, referring particularly to the practice of reducing rains crop by leaving tea unplucked for a period during the rains, and subsequently skiffing, to bring the tea into plucking again.

Mr. Cooper said that experiments in Assam showed that skiffing leaving one or more leaves above the previous plucking level produced better autumnal quality but less crop. The more leaf left, within limits, the better the autumnal quality and the less the crop. By skiffing down hard leaving no new leaf, the same autumnal crop would be obtained as from continuously plucked tea, but quality would not be improved.

Mr. Graham also asked about the effect of skiffing on the subsequent health of the bush.

Mr. Cooper said that if no leaf was left there was no good effect, but with one or more leaves left there was a very definite good effect.

Mr. Fegan asked how this system of skiffing would affect autumnal quality in the case of China tea.

The Chairman *replied that there was no information available; he thought however that the effect was likely to be the same as with other varieties of tea.*

Mr. Cooper *said that harder plucking was commoner now-a-days in Darjeeling than formerly but he thought that lighter plucking ought to give better autumnal quality.*

Mr. Allan referred to the fact that 15 years ago a system of plucking common in the Dooars, was one where the bush was plucked first to 3 big leaves then to 2 and then to 1, coming down to the janum as late as August. The difference between this style of plucking and the closer plucking at present in vogue might account for the poorer Dooars autumnal quality of recent years.

Mr. Boyle asked whether quality would be as good from tea pruned annually but cleaned out at intervals of only 2 or 3 years, as it is in the case of tea cleaned out every year.

Mr. Cooper thought that in the years when the tea was not cleaned out, quality would be little if at all better than that from bushes not cleaned out at all. We had no evidence of this, but, going by the appearance of the shoots, there was little to choose between the shoots from bushes never cleaned out, and those from bushes cleaned out at intervals of 2 or 3 years, during the season when they were not cleaned out. This was the case in Assam, and he thought that it was probably the same in the Dooars.

FIELD EXPERIMENTS IN NORTH EAST INDIA WITH SPECIAL REFERENCE TO COMPOSTS AND SIMILAR MATERIALS.

The Chairman called upon Mr. Cooper to address the meeting on the subject of "Field experiments in North East India with special reference to composts and similar materials".

Mr. Cooper *addressed the meeting as follows :—*

"The position taken up by Sir Albert Howard and his supporters is that, as a result largely of speculation, they have arrived at the conclusion that tea soils must receive organic matter in bulk. They agree, (at least I think they do, although their position on this matter is not quite clear), that the main value of this organic matter lies in the nitrogen supplied, but they ascribe at least a very large part of the wonderful effect which they expect, (1) to improvement in the physical condition of the soil, and (2) to certain auxiliary food factors produced during the rotting (or fermentation) of the organic matter in heaps, or in pits, before application to the soil. They know also, from other people's work, that crude organic matter, with little nitrogen and a lot of carbon compounds, will not provide nitrogen in a form available to plants until, after rotting, most of the organic matter has disappeared. They presume that this loss of organic matter must be completed before the finished product is applied to the soil, not only to render the nitrogen more available, but because some unspecified compound of value is synthesised in a compost heap but not when the same materials rot in the soil. It is suggested also that the presence of animal excreta is essential for the formation of this compound.

They assume (1) that the use of artificial forms of nitrogen is detrimental, and (2) that any tea garden can be self-supporting in manure supply, by using waste vegetable materials available within its own area.

I will state briefly what our hypotheses on the subject now are.

We agree that the use, with discretion, of waste material as manure will effect savings in the manure bill, and that the maintenance of a reasonable content of organic matter in the soil is desirable, as giving more desirable physical condition, as some insurance against severe drought, and as a reserve of nitrogen if artificial manuring has to cease. The possibility of production, during rotting of organic

matter, of useful auxiliary food factors is strong; though the presumptions on the present evidence are that they are essential only where the normal inorganic foods are present in badly balanced proportion, and that they cannot assist at all where deficiency in any one of the essential inorganic foods is acting as a limiting factor in normal development of a plant. We can see no reason for the suggestions that such auxiliary food factors are not formed when organic matter rots in the soil itself, nor can we see that animal intervention is essential.

We claim that the attackers of inorganic manures have not only no evidence at all in support, but a large mass of sound evidence against them. The attacks, we believe, are made in ignorance of the large additions of organic matter as prunings, made in normal North Eastern practice. The assumption that annual prunings will give better results if first fermented away from the soil than if buried direct, is unwarranted by the evidence, while the evidence is clear that preliminary formentation of such materials as green manure cuttings will give worse results than direct burial where they fall.

I cannot in the brief space now available deal fully with the evidence for and against all the many hypotheses involved. I hope merely to convince you that it is necessary that these hypotheses should be tested. We cannot accept them as established theories only on Sir Albert Howard's authority. I will, in the course of this address, show that Dr. Harler's excellent account of his experience on the subject in South India affords no support to Sir Albert Howard's hypotheses, assuming that you have read Harler's speech. If you have not, you should.

The only sound method of scientific advance, is first to consider all the facts available, and on these facts to form what is called a "hypothesis", that is, the best guess one can make which serves to explain all the known facts. It is then necessary to perform experiments to test the hypothesis. When a hypothesis has been well tested it is dignified by the name of a theory. That theory serves to guide us, until it breaks down under some new test, when the theory is modified. A well-tested theory seldom has to be abandoned. It more generally is expanded to include more truth.

The formation of hypotheses has gone on from the earliest days. Up to the time of Bacon it was not generally recognised that hypotheses must be tested by

experiment. The result was that it was generally accepted, for example, that the world is flat, and the sun goes round the earth. Not very long ago, anybody who questioned a hypothesis duly supported by authority was burnt at the stake, or suffered some other unpleasantness.

Tocklai has not suffered any persecution for failure to back all Sir Albert Howard's hypotheses. On the contrary, the Agency which has made the greatest use, in North East India, of the valuable suggestions for greater use of waste vegetable matter, encourages us to go on testing these hypotheses, by allowing the use of parts of four of its gardens for experiment, and by taking the keenest interest both in these and in other experiments on the same subject. Since, however, a number of leaders of the tea industry, particularly in London, are inclined to overvalue organic manures and to undervalue inorganic manures, and are prepared in consequence to spend more than is necessary to maintain their properties, we should not be doing our duty if we did not draw attention to the existing evidence on the subject.

Unwillingness also is expressed to accept the methods which experimental stations are using to test hypotheses. We can only think that this is due to a want of knowledge of these methods, and I propose therefore to explain the methods rather than to give you all our results to-date. After all, we regard the matter as still under investigation: the opinions we now hold are only the best guesses we can make on the present evidence, and may be changed by the results of the tests now in progress.

I will not refer in detail to tests on humus composts. These have progressed only one or two years. Cattle manure is a form of humus compost, and I choose experiments on cattle manure because they have now progressed for a considerable time.

I will take in some detail an experiment conducted at Halem T. E. by Mr. Burton, who is here to-day.

He planned this experiment without reference to us. We heard of it only when he reported the results, as a matter of interest, at the end of the first year, 1938. I am quite sure that he had read no advanced mathematics on the theory

of sampling, nor any papers on the statistical tests to be applied to the results of experiments. Yet, using his common sense, he planned his experiment by one of the methods evolved by the eminent Statistician, R. A. Fisher, which methods have been greeted with enthusiasm by statisticians as a great advance, and by workers in every branch of science as exactly what they wanted. My point here is that these methods are common sense methods, and the fact that they have been proved to have a sound mathematical basis surely should not be held to reduce their value.

Mr. Burton had a great belief in the virtues of cattle manure compared to artificials for his sandy soil, but he was not prepared to accept the results of his conviction based on prejudice only. He decided to test the one against the other.

He laid out 21 half-acre plots in a long line. The first plot got 100 mds. of cattle manure, the next nothing, the next an artificial mixture supplying 20 lbs. nitrogen as sulphate of ammonia. We thus have the three treatments in one block of 3 plots. The six other blocks, of three plots each, were laid out in the same manner.

Plot treatment.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c
	block 1			block 2			block 3			block 4			block 5			block 6			block 7		

a = cattle manure

b = no manure

c = artificial

In this plan there is one mistake which would not have been made if it had first been referred to us.

Suppose, as often does happen, that the land was naturally richer on the left hand side, and became poorer towards the right: in that case the "a" plots would have an advantage over the "b" plots, and the "b" plots over the "c" plots, which would be counted as an effect of the treatment, although really due to originally better soil.

The right method is to keep all three treatments within each block, but to "randomize" treatments within the block. That is, some method of chance selection must be used. I need not go into details of such methods. Using one of them I got this plan which would have been much better.

b	a	c	c	b	a	b	c	a	a	b	c	a	c	b	c	a	b	a	b	c

The results at Halem at the end of the first year (1933) showed that the plots to the left were getting a very slight advantage in soil; but it was very slight and has since become even less, so that the error on this account proves in this case to be of no importance.

After applying the recognised tests we had to report that the experiments at the end of one year had proved no significant effect from either manure; but that as the effects of manuring on tea, in our experience, always proved cumulative, we expected that differences would soon prove to be outside experimental error.

The results in lbs. leaf per plot for season 1937 are:-

	cattle manure.	no manure.	artificial.	block totals.
Block 1.	2397	2081	2460	6939
2.	2350	2138	2487	6975
3.	2360	2073	2566	6999
4.	2465	2030	2447	6942
5.	2292	2100	2406	6798
6.	2254	2009	2359	6622
7.	2293	2222	2364	6879
totals per treatment.	16411	14653	17089	48153

Looking at the block totals, we get an idea of the "fertility drift". Blocks 5 to 7 are poorer than blocks 1 to 4, but differences are small, and there is no steady drop.

Comparing cattle manure with no manure, we see that we get a higher yield from the cattle manure in every one of the seven comparisons. It requires no mathematician to assure us that the cattle manure really has been effective.

Although in block 7 the effect of cattle manure appears very small, we are ready to believe that in some cases the unmanured plot must have been originally better than the adjoining cattle-manured plot.

Comparing the artificial with the cattle manure, we see a higher yield from the artificial in 6 of the 7 cases. This might be good enough for most of us; but statisticians are more particular. If for example we found large differ*ences in favour of the artificial in some cases, and very small difference in other cases they would say: "These results are so irregular that we do not trust them, without a test". This test is provided by Fisher's "analysis of variance". I will* not spend time on its details. By applying it, we find that what is called the "standard error" of the difference between totals of 7 plots is 262.107.

The difference required for significance between totals of 7 plots is $262.107 \times t$. "t" has to be looked up in statistical tables.

For odds of 99 to 1 against the occurrence of a particular difference by chance error, "t" $= 3.055$ $\quad 262.107 \times 3.055 = 800.7$

The difference between cattle manure and no manure is 1758 lbs.

" " " artificial " " " " " 2436 "

The odds then greatly exceed 100 to 1 against the chance that the difference observed from either manure can be due to anything but the effect of the manure.

The difference between the artificial and the cattle manure is 678 lbs.

678 is less than 800.7. If then we were to repeat this experiment 100 times with the same degree of accuracy we should expect a difference of 678 to occur at least once, when in fact there was no difference between the treatments.

For odds of 19 to 1 against the occurrence of a particular difference by chance, $t = 2.179$. $\quad 262.107 \times 2.179 = 571.1$.

571.1 is less than our observed difference of 678 lbs. A difference of 678 lbs. would occur by chance less then once in every 20 trials similar to this at Halem. These odds are accepted as indicating a reasonable approach to certainty.

Mr. Burton then *proves* 16000 lbs. of cattle manure per acre to give less effect then 340 lbs. per acre of artificial mixture in the fifth year of continuous annual addition at Halem.

If he had used single plots, no matter how big, we could apply no test; we could only see that there were differences in yield for different treatments, but could have no idea whether the differences were or were not due to original differences in soil or bushes, or to some chance accident. The difficulty of keeping all other factors alike except those to be compared, becomes greater as plot size increases. The difficulty of sampling the soil itself to see what has happened to, e. g., its acidity or its organic matter content, becomes so great, when very large plots are used, that comparison is almost impossible unless differences are very great indeed. The only difficulty with small plots is accuracy of weighment, and that is easily got over with sufficient care, and use of suitable scales.

For experimental stations, the use of small plots is imperative on account of cost. We have two experiments each demanding the use of 144 plots, and another of 128 plots. If each plot is to be 10 acres, you must give us 4160 acres for these three experiments alone. As it is, they occupy 17 acres, and results are just as accurate, if not more accurate.

Every year Mr. Burton has taken 3 independent samples of the cattle manure at the actual time of application. The samples are sent to us in sealed bottles for analysis and so we know exactly what has been applied as cattle manure.

	lbs. per acre applied as cattle manure at Halem.					
	1933	1934	1935	1936	1937	average lbs. per acre annually.
nitrogen	102	117	92	85	55	90
phosphoric acid	82	53	43	64	...	60
potash	62	66	55	78	...	65
dry organic matter	2500	2488	1843	1795	2101	2145

Against this the artificial mixture has applied annually

nitrogen	40 lbs.
phosphoric acid	20 lbs.
potash	20 lbs.

In the early years, comparison of cattle manure with artificial would not be fair, because larger residual effects would be expected from the cattle manure; but in the fifth year the increased yield is from the 1937 application plus residual effects from the applications in 1933, 1934, 1935 and 1936.

If the residual effect of the cattle manure is in reality much the greater it must be counting greatly in the 1937 yield, so that comparisons between artificial and cattle manure are valid. We get :—

Annual average dressing per acre.	Increased crop in fifth year		mds. tea gain per 10 lbs. nitrogen.
	lbs. green leaf per 3½ acres.	equal to mds. tea per acre.	
90 lbs. nitrogen per acre as cattle manure	1758	1·41	0·16
40 lbs. nitrogen per acre as sulphate of ammonia	2436	1·96	0·49

We find at Borbhetta that, both with cattle manure and with sulphate of ammonia, the effect on crop is proportional to the amount of manure applied, up to much higher limits than are reached here. The comparison of efficiency per 10 lbs. of nitrogen is therefore legitimate.

It will be seen that at Halem in the fifth year of experiment cattle manure has an efficiency per unit of nitrogen about one-third of that of sulphate of ammonia.

At Borbhetta we get on adjoining sets of plots in the seventh year :—

	Increase in mds. tea	
	per acre.	per 10 lbs. nitrogen.
40 lbs. nitrogen as sulphate of ammonia	4·58	1·16
60 „ „ „ „ „	6·88	1·15
60 „ „ cattle manure	3·44	0·57
120 „ „ „ „ „	6·54	0·54

At Tulsipara we get in the seventh year of continuous application :—

		increase over no manure.
5 tons cattle manure (about 90 lbs. nitrogen) (always very dry)		3·42
Artificial	(40 lbs. nitrogen)	3·29

At Borbhetta and Tulsipara, then, we get about half the efficiency per unit of nitrogen from cattle manure that we get from sulphate of ammonia.

On the evidence to-date we cannot give cattle manure any higher value per unit of nitrogen than one half that of sulphate of ammonia.

On this basis we can give cattle manure with ½% nitrogen a value of Rs. 9/- per 5 tons including application. Where you can apply it cheaper than that, as Mr. Burton does, you need not fear that you are wasting money, even if your soil requires only nitrogen. When we find a tea soil which benefits from potash or phosphoric acid, we can increase our estimate of the value of cattle manure for that soil.

Our own trials with humus composts have been in progress only a short time, and results of any others there may be have not been published or otherwise made available to us. So far, our results indicate a lower value for humus composts than for cattle manure, but at present we are prepared to say only that we cannot expect a higher value.

Our estimate of a value of Rs. 9/- per 5 tons applied does not prohibit the use of either humus compost or cattle manure. In estimating costs, we agree with Harler that the cost of any operation (e.g. line cleaning) which would have been necessary whether compost were made or not, should not be charged to the manure. Neither should the cost be charged of that portion of the labour for which there is really no other remunerative work, when this labour would have to be paid in any case.

Harler's figures indicate that the gardens with which he is associated spent about Rs. 60,000/- on the preparation and application of humus composts in a year. Our results would indicate, again on Harler's figures, a value of Rs. 36,000/- for the 20,000 tons compost applied. If however that Rs. 60,000/- really would have been spent on useless work but for making of composts, there is a clear saving of Rs. 36,000/-.

We do not think that N. E. Indian gardens can generally supply their whole manure requirements, as compost, unless those requirements are small ; either because a small crop is wanted, or because a moderately good crop dependent on shade trees is considered satisfactory. The manure requirements for a full crop can be supplied as compost only on a few gardens exceptionally favourably situated in respect of supplies of vegetable material and urine, and with such an excess of labour as would appear financially very undersirable.

We have not the excess of male labour that South India has, because in North East India the men have been taught to pluck, but at times we have excess labour which can be used to increase the supplies of cattle manure by making composts.

Those of you who decide so to use labour really in excess cannot do better than follow the clear directions given in Harler's lecture. Since you cannot control your humus manufacture by analyses and will deal with many different kinds of material you will sometimes go wrong but you will not go far wrong. Results at Allynugger and Borbhetta also offer comfort. Moderate quantities (5 tons per acre) can be applied to the land, unfermented, not only without loss but with advantage. Carriage of bulky cut jungle is too expensive to make this a general practice ; but compost heaps, made in any convenient place, can be carried off to the land as soon as they have settled down to moderate bulk. There is no need to leave them till the white-ants get them, in the hope of getting stuff of the consistency of cattle manure. The main trouble on estates with few cattle (and those not controlled as they are in South India) of getting the urine, will remain. It does not appear generally to be realised that the solid excrement has so little excess of nitrogen over carbon compounds as to be of little value for rotting jungle. It is the readily available nitrogen in urine (which quickly becomes ammonia) which is needed.

In Harler's speech there is little which I would question.

The assumption, implied by his comparisons of humus compost with oilcake and sulphate of ammonia, that they all have the same value per unit of nitrogen, is not justified ; but it is a great improvement on the extravagant claims made by Sir Albert Howard.

We will not quarrel with his gibe "if you have an N. P. K. mentality", because what he goes on to say shows that he is sufficiently hard headed to appreciate the

fact that whatever auxiliary food factors may assist the growth of a plant, its growth and proper development are limited by the amounts of nitrogen, potash and phosphoric acid available to it. The truly "compost-minded" appear to look upon recognition of this fact as a sin.

I cannot deal now with the mass of conjecture in which Sir Albert Howard indulged following upon Dr. Harler's generally excellent lecture, but I must refer to one more point brought up at that meeting.

Harler stated, in reply to a question, that "they never took green stuff out of the tea area for composting, since it was usually of a fine nature with a low C/N ratio". This, we consider, must be an essential feature of the preparation of composts for tea : whatever is used must be additions of plant food from outside the tea area, not material taken from the tea land, and returned to it after expensive treatment which we claim to be unnecessary in the case of annual prunings of tea, and detrimental in the case of green manure cuttings. In the case of prunings of three-years old wood, composting, though difficult and slow, probably would be beneficial but the expense of composting might prove avoidable by carrying available nitrogen (as urine or in some other form) to the prunings in the field, rather than carrying the prunings to the urine and back again.

With regard to the effect of prunings as manure, we have an experiment at Borbhetta which has now completed its third year. The importance which might one day be attached to this experiment was not realised at the time, when we decided to devote 16 plots left over from another experiment to this trial. We wish, now, that we had, not bigger plots, but more repeats of each treatment, so that accuracy would have been greater ; but these plots will serve to explain methods of field experiment all the better because there are so few of them. I could not in a few minutes explain experiments using as many plots as most of our experiments do.

The sixteen plots were divided into four blocks of four plots each, each treatment occuring once in each block. The plots had all been treated alike for some years before the experiment started in 1935.

In 1933 and 1934, when all were treated alike, yields had been as shown in Table 1.

Table 1. Preliminary yields.

		Treatment "a"		Treatment "b"		Treatment "c"		Treatment "d"	
			mean yield		mean yield		mean yield		mean yield
Block 1.	1933	375	375	367	368	325	333	323	318
	1934	375		368		341		313	
" 2.	1933	339	337	339	337	370	364	390	388
	1934	335		335		358		386	
" 3.	1933	364	360	395	390	410	410	406	415
	1934	357		386		411		424	
" 4.	1933	383	382	367	374	362	361	348	342
	1934	382		382		360		335	
Total yield per 4 plots.			1454		1469		1468		1463

We know, then, that the total yielding capacities per 4 plots were very closely alike when different treatment started in January 1935. It does not follow that they would have remained alike had they continued to be treated alike, but we have done our best.

In January 1935 we removed the prunings from 8 of the plots and let them stay on the other 8 plots. To four of the plots where prunings stayed, and to four of the plots from which prunings were removed, an artificial mixture providing 40 lbs. nitrogen per acre was applied. The other eight plots received no artificial. The same was done in January 1936 and again in January 1937.

The yields for 1937 were :—

Table 2.

	Treatment "a" prunings buried with artificial	Treatment "b" prunings buried no artificial	Treatment "c" prunings removed no artificial	Treatment "d" prunings removed artificial given.
Block 1.	316	219	123	207
2.	271	170	126	254
3.	314	244	208	276
4.	374	253	156	235
Total per 4 plots.	1275	886	613	971

Treatment "a" is better than the next best "d" in every block. We might accept it as the best without any test. Similarly we might accept treatments "b" and "d" as each better than "c". But what about the difference between "b" and "d"? "d" gives the better total, but "b" is better than "d" in two blocks out of four. We want some test to decide in such cases.

If we look back to Table I of the preliminary yields and compare the individual plots of treatments "b" and "d", we see that in block 1. where treatment "b" is a little better than treatment "d" in 1937 it was a lot better in 1933 and 1934, and the same is the case in block 4. We get a closer approximation by comparing the drops in crop between the preliminary yields and those for 1937.

	Drops in crop between 1934 and 1937	
	treatment "b"	treatment "d"
block 1.	149	111
2.	167	134
3.	146	140
4.	121	107

Then we see that treatment "d" is the better of the two treatments in each of the 4 cases. Here we have compared, not the 1937 crops (which we will call "y"), but the differences between them and the preliminary yields (which we will call "x"). We have compared $y-x$ in each case. But it is a mathematical fact that we ought to compare not $y-x$, but $y-bx$, where the factor "b" is calculated from the figures themselves. This comparison is known as "the analysis of co-variance (or correlation)" and by its use we get an accurate estimate of the difference required for significance. In this case it is 85, and hence we judge the results of all 4 treatments to be significantly different.

The factor "b" is found to be 0·9593. We usually find it to be not far from 1, when crops for two whole seasons are compared, so that we were not far out in considering differences. When the preliminary yields are so closely alike there is little need to make any allowance for differences between them, but there is no need that they should be alike, and if they are not alike the allowance is made in the following manner.

treatment.	prelim. yields.	x difference from prelim. mean.	bx b = ·96	y actual yields 1937.	y-bx adjusted yields 1937.	equal to mds. tea per acre ·00872 (y-bx).
(a) prunings and artificial	1454	−9·5	−9	1275	1284	11·20
(b) prunings alone	1469	5·5	5	886	881	7·68
(c) neither	1468	4·5	4	613	609	5·31
(d) artificial alone	1463	−0·5	0	971	971	8·50
prelim. mean =	*1463·5*	Difference required for significance.			85	0·74

In our reports we should quote only the last column, which assumes that 100 lbs. leaf would give 22½ lbs. tea.

These figures are interesting enough, but look at them this way :—

	mds tea per acre		difference due to prunings.
	with prunings.	without prunings.	
with artificial ...	11·20	8·50	2·70
without artificial ...	7·68	5·31	2·37
difference due to 40 lbs. artificial nitrogen	3·52	3·19	

You will see that the effect of the prunings is very little more with the artificial than without it. We can test the significance of what difference there is, and it does not approach anywhere near significance. We wish we had more plots to be surer that there is not some small difference, but it is clear that prunings do not require added available nitrogen to allow the soil to make use of them. The soil can deal with this quantity of prunings (about 4 tons per acre containing about 1¼ tons dry organic matter and 60 lbs. nitrogen). It has done so in each of the three years without at any time showing even a temporary depression of crop, but on the contrary showing increased crop where prunings were buried,

from the very beginning of the season. Mr. Pizey at Nyagogra has tried (a properly replicated trial) composting of prunings with cattle manure, against direct burial with cattle manure, and found only a loss from the composting. We do find that there is a temporary loss of crop where prunings from tea giving 20 mds. per acre are buried; but we advise that prunings from normal good tea should be buried where they fall, and not first composted.

Similarly the artificial, so far, does as well on soil deprived of organic matter as where prunings also are buried. I shall be surprised if we do not eventually find trouble where no organic matter gets into the soil, although it is a fact that in none of our experiments can we find any trace of benefit from any form of organic manure compared to sulphate of ammonia. We find in fact sulphate of ammonia to give the better results, and in one case comparisons extend over 18 years. This probably is because we bury prunings.

We can measure soil organic matter only very roughly. It is a complex mixture of varying composition. Very roughly, 100 parts contain 50 parts carbon and 5 parts nitrogen. Any rise or fall in the carbon or in the nitrogen content of the soil therefore indicates a rise or fall in soil organic matter. A rough test which appeals to anybody is to burn off the organic matter from the dried soil and measure the loss in weight. It is not a good absolute test, because this loss of weight includes water driven off from soil minerals during the high temperature of ignition but not during the drying at lower temperature. But this loss of water from minerals is constant for the same soil and therefore the test is quite good for comparative purposes.

We have tried this on the plots of which I was last talking. Here are the results :—

Loss on ignition per cent of dried soil.

	a prunings buried with artificial.	b prunings only.	c nothing.	d artificial only.	block means.
block. 1.	2·59	2·55	2·15	2·23	2·38
„ 2.	2·35	2·52	2·30	2·30	2·37
„ 3.	2.58	2·49	2·23	2·05	2·34
„ 4.	2·15	2·25	2·13	2·04	2·14
mean per treatment	2·42	2·45	2·20	2·16	

You will see that sampling error is high so that the agreement between repeats of the same treatment is not good. It is a good thing that we have our test of significance. This shows that no difference between means of less than 0·09% can be regarded as significant, "a" and "b" are alike within experimental error and so are "c" and "d". The application of the artificial has so far made no significant difference to soil organic matter, but the burial of prunings has made a big difference. The difference of 0·2% is something like 6,000 lbs. of soil organic matter per acre after only 3 years of addition of prunings.

Can we really expect a lot from the occasional addition of 5 tons humus compost containing not more than 1500 lbs. of organic matter on top of this, knowing that half of it at least will not remain in the soil?

This is what we got with cattle manure.

	loss on ignition per cent of dried soil. averages of 6 plots.
No manure	2·23
5 tons cattle manure for 6 years	2·22
10 tons cattle manure for 6 years	2·48
20 tons in 1931 only	2·13
difference required for significance	0·24

We can prove no increase in soil organic matter either from the 20 tons in 1931, or from six additions of 5 tons. This does not mean that there are not increases, but they are too small for this method to discover them.

Six additions of 10 tons do make a significant difference to soil organic matter although prunings also were buried.

I will quote only one more experiment giving results in 1937 of continuous annual application of the same quantities of nitrogen in different forms for 18 years.

	mds tea per acre 1937.	loss on ignition per cent of dry soil, 1937.
Sulphate of ammonia	12·88	3·33
Boga medeloa cuttings	11·56	3·27
Oilcake	10·30	3·23
Nervox (sinews and hide)	7·83	3·13
Nitrate of Soda	6·67	2·98
No manure	5·88	2·99
Difference required for significance	1·41	0·26

These results illustrate a number of points of interest. There is no detrimental effect from long-continued use of sulphate of ammonia either on crop or on soil organic matter content.

The boga medeloa cuttings are always hoed in immediately as cut. They have never produced any "poisoning effect" ; on the contrary they produced great good effect as soon after application as nitrate of soda (the quickest acting of all manures). They have not increased soil organic matter more than sulphate of ammonia. We cannot keep our cake and eat it too. We cannot expect nitrogen to be active in crop production and also to stay in the soil.

Oilcake gives significantly less effect on crop (and, you will agree, on health and general appearance) than sulphate of ammonia, and its use has not increased soil organic matter more than have the prunings produced by sulphate of ammonia.

Those who want slow action can get it by using such materials as sinews and hide, but they will spend much more than they get back, even after 18 years.

Nitrate of soda did just as well as sulphate of ammonia from 1920 till 1932. Then the bad effect of soda on soil tilth began to show up and these plots now look worse than those never manured. We believe the distrust of inorganics formerly exhibited by British farmers to have been founded on observation of these bad secondary effects.

We may eventually find bad effects, from the depletion of the soil of lime and other bases, where sulphate of ammonia is used for a very much longer time. If we do, we know already how to avoid such effects without extra cost, by the occasional substitution of calcium cyanamide for sulphate of ammonia. We have, in fact, for soils judged already to be sufficiently acid for tea, advised this procedure, in order to be on the safe side.

Now that adverse secondary effects are understood and can be avoided, the British farmer uses inorganics practically entirely, in addition to his farmyard manure. He understands soil management and the value of grass (including clover) in the rotation. I would guess that, in the cases where artificials are stated to have caused the soil to go "on strike", it was soil management rather than artificials which was at fault.

If we keep our soils fully occupied by good tea, keep our prunings on the land, and use shade trees in moderation, we have all the essentials of good soil management. My opinion now is that we can maintain splendid tea with no organic manure at all; but we can reduce our bills for artificials to still more moderate proportions by applying to the land all the waste organic matter we can, so long as the cost is not greater than that of artificials giving the same effect".

DISCUSSION.

Mr. Nicholls asked if it was not a fact that cattle manure had the effect of reducing soil acidity and if this was so, whether its lower efficiency compared to sulphate of ammonia could be ascribed partly to this fact, particularly on soils already low in acidity like the sandy soils of the Bishnath district.

Mr. Cooper stated that the soil on which the experiments at Halem were being done was acid, and experiments at Tulsipara and Borbhetta where the soils were also acid, gave similar results to those at Halem. He agreed, however, that on soils already so low in acidity as to be close to the range within which tea did not grow well, it would be a mistake to apply large dressings of cattle manure, thus rendering the soil still lower in acidity. He also mentioned the fact that sections of tea near lines, which naturally got heavier applications of cattle manure

than sections further away from the source of the manure, were often found to be low in acidity, and further applications of cattle manure to such areas would very probably be harmful.

Mr. Cullen then read out a letter from the Secretary, Chutla Bheel District Committee as follows :—

> "Will secondary jungle growth such as ageratum * etc. collected from the dharies and sides of tea flats, and then laid in the gulleys between the tea bush rows, and allowed to rot, not be of as much use to tea as a manure, as is the usual compost mixture advocated by Sir A. Howard ; all Managers of course appreciate the fact that this jungle is liable to fire, if collected in the cold weather, one would have to do it at the first break of the rains."

Mr. Cooper said that in the case of such waste jungle as "Giant Ageratum" etc. the ratio of carbon to nitrogen was too high when it was applied to the soil direct, and that a temporary depression of crop might be expected after application of such jungle in any large quantity. It would be perfectly safe, however, if additional available nitrogen were applied, preferably in an alkaline form (e. g. calcium cyanamide) along with the jungle to make up the carbon nitrogen ratio to the figure considered satisfactory for decomposition of vegetable matter. Small quantities, say 5 tons, of the crude material, could be applied in the manner suggested without additional available nitrogen.

Mr. Cooper in replying to questions put by Dr. Wight and Mr. Graham said that by not burying prunings, but leaving them to lie on the soil, small loss in crop had occurred after seven years of this treatment. The differences, however, were not as yet significant and showed no signs of increasing. He thought that there was a slight benefit from hoeing in the prunings as compared with leaving them to rot on the surface, but this had not been proved.

The Chairman said that in connection with the question of the value of composts and bulk organic manures generally, Prof. Gericke's experiments in America in which he was able to grow excellent crops using mineral solutions only without any organic matter, or even soil, were of interest.

---

* Probably the plant Eupatorium is meant here ; it is sometimes called Giant Ageratum.

SPRAYING FOR BLACK ROT DURING THE COLD WEATHER.

The Chairman then called upon Mr. Tunstall to address the meeting on the subject of "Spraying for Black rot during the cold weather". This was in answer to a question sent in from one of the tea districts.

Mr. Tunstall addressed the Meeting as follows :—

"For many years we have been deceived in regard to the effect of the cold weather treatment of this disease. Since it has been possible to carry out systematic observations extending over long periods we have found that this disease reappears year after year on the same individual bushes when the climatic conditions become favourable to the growth of the fungus i. e. usually about August. Comparatively few newly infected bushes are found. It was assumed previously that the sudden appearance of black rot at that time was caused by new infections. It is however mostly the result of the revival of the fungus.

Spraying.

Spraying in the cold weather with either Burgundy mixture or Lime sulphur solution does not prevent the revival but in some cases it appears to delay it for a few weeks.

On a garden in Cachar all the bushes on the treated plots were sprayed on April 30th. Significantly fewer infected bushes were observed on the treated plots in May but in June there was no difference at all. The same plots were sprayed again on August 1st. The results of this spraying were very marked not only in the succeeding months but also throughout the next season in the case of the plots treated with 1% Burgundy mixture. Lime sulphur solution did not give such good results.

On a garden in Upper Assam the treatments which included Burgundy mixture and Lime sulphur solution were applied to all the bushes immediately after pruning. The numbers of bushes found to be infected on the treated plots in the course of the following season did not differ significantly from those on the check plots. It must be assumed therefore that the application of either Burgundy mixture or Lime sulphur solution in the cold weather has little permanent effect on the incidence of Black rot in the following growing season.

Until we find a more efficient spray fluid for application in the cold weather we do not recommend spraying at that time for the treatment of Black rot. Our experiments have shown clearly that good results are obtained by spraying individual bushes with 1% Burgundy mixture whenever the disease is seen to be active. Lime sulphur solution is not so efficient as Burgundy mixture for the treatment of this disease.

Removal of prunings.

Another point on which we have sought information is the effect on the incidence of Black rot of removing and burning the prunings of infected bushes. An experiment carried out in Cachar showed that the removal and burning of all the prunings from infected plots did not have any effect on the recurrence of the disease in the following rainy season. We do not therefore recommend the removal and burning of the prunings.

Cleaning out

On two of the gardens on which experiments have been carried out the bushes are carefully cleaned out each cold weather. No reduction in the incidence of the disease occurred on the check plots. It may be assumed therefore that the cleaning out has no appreciable effect on the Black rot."

DISCUSSION.

Mr. Burton asked whether the fact that cold weather spraying was an unsatisfactory treatment for Black rot, was due to the inefficiency of the spray fluid or to inaccessibility of the fungus disease itself.

Mr. Tunstall said that the fungus occurred in crevices in the branches of the bush where it was inaccessible to ordinary spray fluids. What was required was a fungicide of oily nature which would penetrate these cracks in a way which was impossible with ordinary water solutions of fungicides.

Mr. Mackay stated that it was his experience on certain Assam gardens with which he was concerned, that annual cold weather spraying with Lime

sulphur over a number of years had reduced Thread blight from being a serious problem to one which was now of comparatively minor importance.

Mr. Cooper asked if there was any evidence of advantage being obtained from cold weather spraying for any disease. Mr. Tunstall said that we had no experimental evidence in favour of spraying at any time in the cold weather, for Black rot or Thread blight.

Mr. McLennan asked whether spraying was effective on tea which was not cleaned out. Mr. Tunstall said that it was effective as a cure for Black rot if the spraying was done in the rains with 1% Burgundy mixture.

Mr. Nicholls asked about the value of caustic soda, and in reply Mr. Tunstall said that he thought it was useful but should be used on cleaned out tea before the buds had formed, and should not be stronger than 1%, otherwise it was liable to burn even the wood.

Mr. Nicholls referred to the common practice of leaving any diseased bush unpruned during the ordinary pruning round and then afterwards pruning these bushes separately, removing and burning all the leaves and the prunings. This was then followed by spraying.

Mr. Tunstall said that we had no experiment in this connection but thought that there was probably some benefit, at any rate in the case of certain diseases.

Messrs. Graham and Allan referred to the effect of clean pruning, or of removing banjhi twigs by hand during pruning, and asked whether this was considered to be effective in reducing disease.

Mr. Tunstall replied that he thought that this would have good effect by exposing the diseased portions to the action of the sun.

Mr. Fegan stated that he had been successful in killing out Thread blight by two years of treatment of the bushes during the cold weather with the residue left over after making Lime sulphur solution, painted on the bushes over the infected branches.

Messrs. Burton, Allan and Graham all asked whether it might be conceded that, in the absence of definite information, there was scope for experiment under Tocklai supervision on gardens suffering from Thread blight on the lines of experiment carried out in connection with Black rot.

The Chairman agreed that there was scope for such experiments.

The Chairman in summing up the discussion referred to the fact that such experiments as had been carried out showed that there was likely to be better value obtained for the money by rains spraying rather than cold weather spraying in the case of Black rot and Thread blight. Regarding the value of cold weather spraying in general for other fungus diseases there were no experiments upon which more definite advice could be given.

PROCEEDINGS OF A MEETING HELD ON FRIDAY, 18TH FEBRUARY, 1938, AT 9-0 A. M. AT THE TOCKLAI EXPERIMENTAL STATION.

The Chairman in opening the morning's proceedings referred to the fact that the minutes of the previous day's proceedings had been circulated, and that if any of the delegates had any corrections to make, would they kindly communicate them to Mr. Harrison during the course of the day.

DEFECT IN TIP AND IN THE APPEARANCE OF TEAS.

The Chairman called upon Mr. Benton to address the meeting on the subject of "Defects in Tip and in the appearance of teas".

Mr. Benton addressed the meeting as follows :—

"I am dealing with the question of tip, greyness and brown teas largely as a result of requests made by planters who have examined teas microscopically in my laboratory. The subject gains further interest from the list of tea tasters' terms recently published, which appears to me to be incomplete and in some respects inaccurate."

For instance only two references to tip are made viz, "tippy" and "pale tip". If these terms are adhered to, a tea with a reasonable amount of tip must be described as "tippy", whether the tip is bright, dull or silver in colour, and any tip which is unsatisfactory must be described as "pale", even though the defect is a dull brownish colour. Furthermore, according to the published list pale tip is generally caused by over withering. As a matter of fact, it is more frequently produced by underwithering.

It is obvious that if these terms are to fulfil their purpose of enabling the planter to determine the origin of defects in his teas, the list of terms should be comprehensive, and that it is preferable to use separate terms for defects that are different, rather than to group all defects under one heading.

Thus we recognise three main defects in tip, viz, silver, pale and dull ; all are due to different factors and all are readily identified under the microscope.

I therefore propose to give you a brief address on the subject of the appearance of teas, showing how the different features are affected by manufacture and indicating the manner in where the cause of certain defects may be determined by observation or by simple tests.

The appearance of bright and dull tip, and of black grey and brown teas depends largely on the fact that the eye cannot distinguish small particles of different colours but obtains an average effect. Thus in an ordinary half-tone photograph the tones which appear to be grey are actually seen under the microscope to be a mixture of black and white squares of varying size.

Tip.

The production of golden tip is dependent on the presence of hairs, which may be largely confined to the bud, or may be distributed over the bud, first leaf and the upper portion of the stem. The amount of hair present is dependent on the jat and on the season or growth period of the bush. If hairs are not present, tip cannot be made. The hairs are normally 1/100 inch long and 1/1000 inch thick and are just preceptible to the naked eye. The hairs are colourless and their presence in quantity gives a silvery sheen to the buds, particularly after withering. If withered leaf has a dull green appearance, tip cannot be made, but if a silvery sheen is evident, tippy teas should result unless the tip is lost in manufacture.

Golden tip.—During rolling, juice is expressed from the leaf and is deposited on the hairs, cementing them together to form a solid mat. After fermentation and firing, true golden tip appears; a microscopic examination shows that the hairs, and the dried juice adhering to them, have now a golden colour and completely cover the black leaf tissues underneath.

Silver Tip.—The cause of true silver tip is at once apparent, for if the wither is so high that no juice is expressed in rolling, the hairs will retain their silvery colour. The remedy is to apply sufficient pressure to express juice in the 1st roll. There is some evidence that if the buds have been allowed to dry and blacken during the course of withering, juice does not readily adhere to the hairs, and silver tip may be obtained even though juice is expressed by hard rolling or when

a little water is added to the roll. Blackened leaf is usually found in conjunction with overwithering.

I cannot agree with the statement made in the glossary of tasters' terms, that pale tip is generally the result of overwithering, for if juice is not expressed during the roll, the tip will be silvery, while if the wither is just sufficiently light to allow juice to appear, good coloured tip should result, since the concentration of tannin and other materials in the juice will then be higher than in a normal wither. Silver tip cannot be called "pale tip" unless one subscribes to the exaggerated theory that white is only pale black, and that black is merely dirty white.

Pale tip.—Pale coloured tip results from conditions which lead to a thin coating of juice being deposited on the hairs. Such conditions may arise when a very light wither reduces the concentration of soluble solids in the juice ; a similar effect may occur when hair development is poor, the hairs being spaced widely over the surface of the bud, with the result that, although the hairs may be coated with juice, they are not cemented together to form a solid mat, as is the case with bright golden tip.

Dull tip.—It is important to differentiate pale coloured tip from dull tip, since the latter defect is brought about by incorrect manufacturing conditions, and is controllable. In the former case, the tip has an even pale golden colour and under the microscope is found to consist of an even layer of hairs with very little juice attached. In dull tip, the colour may be described as dull gold or rusty, and is occasioned by the irregular removal of hairs during manufacture, so that areas of bright gold and black leaf alternate, the eye obtaining an average effect. Under the microscope this feature is very evident, and frequently the tangled, instead of orderly, arrangement of the hairs shows that the condition is due to damage in manufacture.

Dull tip may be produced during rolling or after the first fire. When the shoot contains adequate moisture, the hairs are tough and are able to experience considerable stress without being detached from the shoot. It is very doubtful

if extreme mishandling of fresh or withered leaf is able to remove hairs from the bud. During normal rolling the friction of leaf against leaf rarely does serious damage to the tip owing to the elasticity of the mass of leaf. It is well known, however, that liquids under compression have little or no elasticity, and it is the shearing effect of excessive juice in the roll which removes hairs from the bud.

Under favourable conditions, relatively hard pressure can be given in the first roll without loss of tip, but tip may be lost even in light rolling under certain circumstances. The factor of greatest importance is the charge of leaf in the roller. With a reasonably light charge of 3½ maunds, considerable pressure may be applied without packing the leaf, and even under pressure the leaf rolls both on the table and on the cap. With a normal wither, juice is expressed in small quantity in the form of froth, and it seems probable that the presence of air bubbles in the froth avoids the shearing propensities of the juice.

With an over-charge, the leaf packs in the roller and fails to turn over. Extreme pressure develops at certain points and watery juice comparatively free from froth may be expressed in quantity. The flow of juice under pressure through the mass of the leaf shears the hairs off the bud and a dull coloured tip results.

It will be obvious that many of the hairs sheared off the bud will be deposited on the coarser particles of leaf during the process of rolling, but never in sufficient quantity to give the appearance of tip. When such tea drops from the dryer it possesses a grey or rusty appearance, due to the increased reflection of light from these scattered hairs. A tea which is grey before sorting and possesses dull coloured tip thus gives a clear indication of over rolling.

Under the microscope, hairs are seen to be distributed over the surface of the coarse leaf, and these hairs point in different directions. Hairs which have grown naturally on the leaf all point in the same direction.

Dull tip may also occur in finished teas when hairs are abraded after firing. In this case, the coarse tea will appear black before sorting. The fluff which is usually present in quantity in the sorting room, consists almost entirely of hairs from the bud together with the minute juice particles which were attached to

these hairs. It is generally recognised that loss of tip may occur in sorting, but the fact that tip may be lost by careless handling after the first fire, is not so widely known.

When tea is dropped from the first fire at 12-14 annas, the hairs on the bud and the juices entrapped by these are almost devoid of moisture and are therefore very brittle. Unnecessary shovelling and handling is to be avoided from this point onwards. It is particularly important to see that the speed of the automatic spreader on endless chain machines used for the second fire is reduced to the minimum which will spread the leaf. 10 r.p.m. is adequate, and avoids the tossing action which is detrimental to tip. When the second fire is carried out on tilting tray machines, the use of bamboo sticks for evening the spread on the top tray should be forbidden. Observation will show that each time the leaf is touched, a cloud of fluff rises from the machine.

Loss of tip may be rapid if the leaf is sorted immediately after firing. On standing overnight, the hairs absorb moisture and are then less brittle. Hairs may still be abraded by any process which allows leaf particles to rub against each other. Overloaded sorters produce this effect, and excessive treatment on China sieves is also undesirable. Experiment carried out recently by the Ceylon Tea Research Institute suggest that abrasion is reduced by the use of stamped aluminium sieves and sorter trays.

The most frequent source of loss of tip in sorting is the use of machines with sagging trays. Where a sag occurs, leaf accumulates in the depression instead of flowing evenly down the tray, and friction between individual particles removes the hairs from the tip.

Burnt or blackened tip.—Small black tips or tips with a streak of gold on the midrib only are sometimes found on tea. The explanation put forward is that the tip has been burnt in firing or has been stained black by the tea juice. Neither of these suggestions will bear examination, for it is very unlikely that tip can be burnt at temperatures lower than 240°F, while deposition of juice on the bud will produce golden tip if hairs are present.

So-called burnt or blackened tip is due to a growth condition. Small banjhi buds are frequently devoid of hair or carry a small amount of hair on the midrib

only, especially in some of the dark-leaved varieties. When banjhi conditions are prevalent on the garden, small black tips or tips with a streak of gold may be expected.

We thus have :—

Golden Tip.—due to a heavy deposit of juice on the leaf hairs.

Silver Tip.—due to overwithering, and failure to deposit juice on the hairs.

Pale tip.—due to under withering or insufficient hair development, a thin film of juice being deposited.

Dull tip. (a)—with greyish leaf, due to abrasion of hair in the roll.

(b)—with black leaf, due to abrasion of hairs in sorting.

Burnt or blackened tip.—due to the presence of banjhi buds, devoid of hair.

Greyness and Brown leaf.

Black tea.—Correctly manufactured black tea before sorting has a characteristic appearance under the microscope. The surface of the leaf is highly wrinkled owing to contraction in firing, and is evenly coated with a varnish-like film of dry juice. This film is transparent ; light falling on the surface passes through the film, to be completely absorbed by the underlying tissues. Absence of reflected light gives the tea its black appearance.

Greyness in sorting.—If this transparent film of dry juice is scratched, minute granules are detached, some remaining loose on the surface and others falling to waste. The particles reflect light on account of their irregular surface, and their minute size makes them appear white. The presence, in any quantity, of these white particles on the black background of the leaf, gives an even grey appearance to the tea.

This form of greyness may readily be identified by exposing the leaf to steam from a kettle for a few seconds. The granules of juice dissolve in the condensed steam and once more form an even coating over the surface of the leaf, which immediately assumes an intensely black appearance.

True greyness is thus produced by any process which allows the surface film of juice to be abraded. Teas sorted immediately after firing usually show this

defect to a marked extent, for the juice film, on leaving the dryer, is dry and very brittle. After standing overnight, the film absorbs moisture and becomes more resilient. Greyness is then developed by continued friction between leaf particles, such as occurs when leaf collects in sagging trays in sorting machinery, when sorters or cutters are overloaded, or when large leaf is cut in small cells, so that each leaf particle travels several times round the hopper before its size is reduced sufficiently to allow it to leave the machine. High speeds in cutting machinery reduce the chances of leaf falling into the cutting cells, and have a similar effect in producing greyness.

Greyness in rolling.—When teas appear grey after firing but before sorting has taken place, the defect is again due to increased reflection of light. In this case however, scattered hairs on the surface of the leaf are responsible. The hairs are usually found isolated from each other, and they do not therefore retain sufficient juice to give them a golden colour. The presence of scattered hairs is due to the excessive shearing stress by juice during the roll, and may usually be attributed to overloaded rollers, specially when the wither is light, or the speed of the rollers too high.

Bloom.—A brownish bloom is frequently found on tippy teas. This is due to hair development on the larger leaves and the stem, insufficient in amount to produce golden tip. Under the microscope, a large percentage of the leaf is found to carry hairs arranged in an orderly manner, bearing juice deposits to a greater or lesser extent. The arrangement of the hairs indicates that their presence on the leaf is natural. Generally speaking, bloom should only appear on very tippy teas. Its presence on teas with poor or dull tip usually signifies overrolling. Seen under the microscope, the hairs on leaf which has been subjected to over rolling are found to be distributed in an irregular manner, which contrasts with the orderly arrangement found in tippy teas.

Brown leaf.—Brown leaf is found in autumnal teas and in leaf which has been manufactured with tobacco cutters, chaff cutters, and the C. T. C. machine.

In ordinary leaf manufactured in conventional machines, most of the leaf particles are twisted in rolling, and consequently, two or more layers of leaf tissue

are superimposed. Light which passes through the first layer is absorbed by the second, and the leaf therefore appears black. Autumnal leaf is hard and does not twist readily. A considerable portion of the tea therefore consists of single fragments of leaf, sufficiently thin to allow some light to pass; the presence of red and brown substances inside the leaf gives a brown colour to the light which passes through the tissue, and a preponderance of such single fragments of leaf gives a brown colour to the mass.

In tobacco cut teas, a similar effect is produced by cutting the leaf into portions too small to roll. The C. T. C. process tears the leaf and stem tissues apart and exposes thin sections of tissue which allow light to pass in the same manner.

Stalk and Fibre.—When lignin is deposited in the conducting vessels of the stem, the stem becomes hard and rigid, although it is still covered by a soft layer of green tissues. Such stems will appear black unless the surface tissues are removed, as in hard rolling, when red stalk will appear. If hard stems of this type are treated by the C. T. C. process, individual strands of xylem are torn out of the woody tissues, and appear in the fired tea as fibre. Fibre can only be avoided by removing the hard stems before submitting the leaf to the C. T. C. process."

DISCUSSION.

The Chairman referring to a point raised by Mr. Benton in the above address said that in several instances, in the published glossary of tea tasters' terms, a certain tea characteristic had been incorrectly ascribed to the effect of a certain factor in manufacture. As this was liable to cause misunderstanding among those using the glossary, he had written to the Indian Tea Association, Calcutta, suggesting that in the published glossary definitions only of the various characteristics should be given and that no attempt should be made to define the factors influencing these characters.

He also referred to the greyness of teas of a certain garden, caused by abrasion of the tea during sorting. In this factory transport of leaf during manufacture had been speeded up, and unnecessary handling of the tea was avoided by using canvas belt conveyors. The tea was thus sorted warm, and in such a

condition the dried coating of juice on the leaf was more brittle and more susceptible to abrasion. It was better not to sort immediately after second firing when the tea was in this condition.

He also referred to the pneumatic sorting system which he had seen in Java. Here the tea was sorted by passing it through a wind tunnel about 30 ft. long and 11 ft. high. This system of sorting was considered not to spoil appearance or to grey the teas.

Mr. Benton asked whether there was a risk of tea sorted in the pneumatic sorter becoming too high in moisture content.

The Chairman replied that there was, and that the difficulty was overcome by using warm air which had its relative humidity reduced to a degree which prevented the tea from becoming too moist.

Mr. Benton referred to experiments which showed that tea kept at 96° F. for 10 days in the rains did not go above 6% moisture.

He thought that the dislike of grey tea shown by the trade might be associated with the loss of liquor due to abrasion of dry juice from the leaf surface.

Mr. Nicholls thought that Mr. Benton's lecture might prove of particular interest to Mincing Lane.

He also asked if it were possible for the Scientific Department to publish a pamphlet dealing with the principles of sorting and the arrangement of tea sorting machinery.

Mr. Burton asked whether the 1927 Indian Tea Association pamphlet on Tea Manufacture, which was now out-of-date, could be revised.

The Chairman said that in view of the fact that the Tocklai factory was not suitable for large scale factory experiments they had not sufficient reliable experimental evidence on manufacturing methods to justify the revision of the pamphlet on tea manufacture. He said that in Ceylon, at St. Coombs factory, small scale experiments could be tested on large scale machinery and they were largely dependent on the Tea Research Institute for information on manufacture methods. The Tea Research Institute of Ceylon had promised to do their best to enlarge their own

experiments to cover conditions likely to be met with in North East India and to give them the benefit of any results likely to be of use to them.

Mr. Allan suggested that as a means of avoiding greyness from the spreader in the second firing machine the spreader could be removed and the tea spread by hand.

The Chairman thought that this was introducing a personal element which it was desirable to avoid, and Mr. Harrison pointed out that if the speed of the spreader was reduced to about 5 r.p.m. there was no fear of damaging the tea.

Mr. Graham asked whether the Department had in view the possibility of taking over a full sized tea factory for some period in order to confirm their own small scale experiments.

The Chairman replied that he had made enquiries in this connection and one difficulty was to get a factory with duplicated machinery. This was essential for carrying out experiments and was likely to be found only in a big factory. He had one such factory in mind and had approached the Company concerned but he thought that his department were not quite at a stage at which it could take over the factory and obtain the maximum value from experiments carried out therein.

Mr. Smart asked whether humidity was the important factor in fermentation or whether temperature was the more important.

The Chairman replied that temperature was the important factor and that humidity was effective on account of its cooling effect.

Mr. Smart asked whether galvanised sheets were preferable to cement floors for fermentation.

The Chairman said that galvanised iron sheets were more easily cleaned and in that respect preferable but that a good cement floor was actually just as satisfactory though more difficult to keep clean.

Mr. Benton said that in view of the need to avoid lead in tea, aluminium sheets were preferable to galvanised sheets.

In reference to the comparative costs of a cement floor and aluminium sheet he said that he thought that aluminium sheets, if carefully looked after and

properly laid down, might last for 15 years. He referred to the very considerable cost of laying down a really good cement floor.

Mr. McLennan thought that Mr. Benton was rather optimistic as to the life of aluminium sheets.

Mr. Benton thought that it depended on whether the sheets were properly put down and correctly treated; this was his own opinion, for which he naturally had no proof.

Mr. Burton referred to the difficulty of spreading leaf in second firing in a Venetian dryer.

Mr. Benton said that if the leaf was spread by hand from a basket it could be spread reasonably evenly. Some irregularity was unavoidable but it probably did not matter in the case of second firing.

Mr. Graham asked if there was any particular virtue in fermenting on an impervious floor such as glass, compared to a pervious one and said that years ago glass had not proved satisfactory.

Mr. Benton replied that *per se* there was no difference. The impervious floor was easier to keep clean and was better in this respect. He said that there was a definite virtue in sterile conditions for fermentation and so far no bacteria which improved teas had been found.

Mr. Benton said he had been told that many years ago the trade showed a preference for teas which were coloury even to the point of sourness. Bacteria in fermentation might produce coloury teas at the expense of other characteristics and hence it might be that fermenting on glass, which gave more sterile conditions, did not prove a success in view of the trade requirements in those days.

SOIL ACIDITY AND ITS RELATIONSHIP TO TEA CROP.

The Chairman called upon Mr. Harrison to address the meeting on the subject of "Soil acidity and its relationship to tea crop."

Mr. Harrison addressed the meeting as follows—

"An important factor affecting plant growth is the degree of acidity or of alkalinity of the soil Acidity and alkalinity are terms in everyday use, and many examples of acids and alkalis will occur to us. Acids are generally characterised by having a sour taste. Alkalis belong to a large class of substances called bases which are all distinguished by their property of combining with acids to form salts. Alkalis are bases which are soluble in water forming soapy solutions.

Acids and bases vary in strength; thus sulphuric acid is a strong acid, and acetic acid is a weak acid; caustic soda is a strong base and ammonia is a weak base. When a strong acid and strong base are mixed, they react together and form a salt and water. If the acid and base are mixed in correct proportions the one neutralises the other, so that the resulting product is neither acid nor alkaline, but neutral.

Thus a solution containing 49 parts of sulphuric acid mixed with one containing 40 parts of caustic soda produces a neutral solution of a salt, sodium sulphate. If therefore we have a solution of acid of unknown concentration we can determine this concentration by finding how much caustic soda of known strength is required to neutralise it. Similarly the concentration of a base can be found by determining how much acid of known concentration is required to neutralise the base.

If a weak acid and a strong alkali are mixed in what should be the correct proportions for them to neutralise each other, it is found that the resulting salt is not neutral but alkaline. Thus carbonic acid and caustic soda form sodium carbonate (ordinary washing soda), which is alkaline, the effect of the strong alkali still predominating. By mixing this salt with sulphuric acid, the latter turns out the weak carbonic acid and forms the neutral salt sodium sulphate.

It may seem that I have rather laboured the chemistry of acids and alkalis, but this aspect is of great importance to a clear understanding of soil acidity.

The acids responsible for soil acidity are very weak indeed, and are due to the clay and organic matter in the soil.

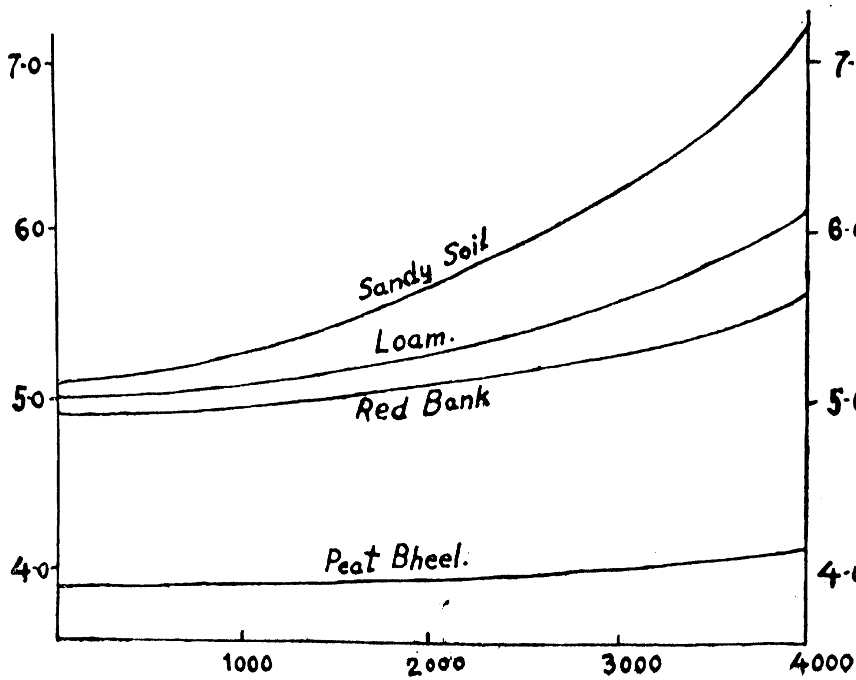
Part of the organic matter in soils consists of substances of an acid character. Part of the clay portion of a soil is in a state of extremely fine division, the

particles being so small as to be indistinguishable even under a microscope. This portion of the clay fraction is termed colloidal clay, and has weakly acidic properties. Part of the organic matter in the soil is in the form of colloidal matter, which has the properties of a weak acid. These weakly acidic constituents of the soil are capable of combining with bases such as caustic soda or lime, forming salts. Soils contain varying quantities of clay and organic matter, and also varying quantities of bases such as lime, potash, soda and magnesia ; and the relative proportions of all these soil constituents determine its acidity.

If we apply a base like lime to an acid soil, the latter becomes less acid or neutral or even alkaline according to the amount of lime applied. Very stiff clay soils, or soils like the Peat Bheels containing much organic matter, are generally highly acid in nature, and would naturally require large quantities of lime to reduce this acidity appreciably. Sands on the other hand, containing little clay or organic matter, may be greatly reduced in acidity by comparatively small applications of lime.

The following curves illustrate the effect of adding lime to various types oftea soils.

pH **Effect of lime on different soil types.**



We measure the acidity of weakly acid solutions by what is called their pH value. I cannot here go into this matter in detail, except to explain that a neutral solution has a pH value of 7·0; acid solutions have values less than 7·0, while alkaline solutions have values greater than 7·0.

This notation is applicable to suspensions of soils in water, and for such suspensions, the value lies between 3·0 (for the most acid soils) and 9·0 (for very alkaline soils).

Very new soils may be neutral or alkaline, owing to the fact that they contain a high percentage of bases which have not had time to be leached out, while there has been equally little time for accumulation of acid organic substances to be formed by decay of vegetable matter. In old soils under virgin forest, leaching of bases has occurred, and large accumulations of organic matter have also become incorporated with the soil. These soils are often highly acid, but lose much of this acidity when cultivated, owing to the further breaking down of the organic matter, thus not only removing the acid organic substances, but setting free a residue of bases.

The soil acidity requirement varies considerably for different plants, as the following table shows.

Optimum pH range for growth of common crops.

Crop.	Growth Range pH	Opt. Range pH	General Remarks.
Potato	—	5·0—5·6	Uninjured at 4·2
Barley	6·5—9·0	6·4	—
Oats	—	5·3—5·8	Injured at 4·3
Wheat	5·2—7·0	—	—
Rye	4·2—7·6	6·2	—
Turnips	5·0—6·5	6·0—6·5	—
Lucerne	6·0—7·2	7·0	Injured below 6·0
Sugar beet	—	7·0—7·2	
Pasture grasses (average)	5·0—6·5	6·0	—
Sugar cane	—	7·0	
Tea	3·0—6·5	(about) 5·0	—

It can be seen from this table that the majority of agricultural crops need a soil very low in acidity, potatoes and oats along with tea being notable exceptions. Potatoes actually do grow better in soils above pH 5·6 but they are then more susceptible to the disease known as "Scab".

We have been able to narrow down considerably the range of acidity for tea since the time when this table was published. It is now recognised that the growth range and optimum value of acidity for tea vary according to the type of soil on which the tea is growing. A very sandy soil of pH 6·8 will grow good tea, whereas on a clay soil or a bheel of the same acidity, tea will hardly grow. The stiffer the soil and the more organic matter it contains, the higher the acidity (or the lower the pH value) required for tea to thrive. The following table gives the range of pH on which good tea is growing, for various soils in N. E. India. The soils are arranged roughly in order of clay and organic matter contents.

Acidities of various types of tea soils.

Soil type.	Clay. %	Loss on ignition. %	pH range for good growth.
Peat Bheel	15	33	3·2–4·8
Heavy clay	33	10	3·8–5·2
Red Bank	25	7	4·0–5·4
Clay loam	16	6	4·6–5·4
Sandy loam	6	3	4·6–5·6
Sand	3	2	4·6–5·8

In the early days of tea, nothing was known of soil acidity and its effect on plant growth, but it was generally well known from experience on other agricultural crops that most virgin soils required lime before they would produce good growth. The need of a soil for lime was recognised by the appearance of such weeds as sorrel, by the disappearance of clover, and by the presence of such diseases as "finger and toe" in turnips. Such land was called "sour" and was made "sweet" by liming. Most farm crops grow best on slightly acid soils, and a slight excess of lime is

better than over acidity. So great was the response of most crops to lime that few would have believed until comparatively recent years that lime would do no good and might do harm to tea. Most Indian tea soils are low in lime by British agricultural standards, and on this account advice on manuring based on home experience stressed the fact that lime was necessary. In spite of this however, Dr. Mann was of the opinion that lime was not necessary on the majority of tea soils, basing this opinion on his experience of results actually obtained from the use of lime on tea. He advised lime only to improve the physical condition of the soil and to eradicate blights.

At this time the fact that the majority of tea soils were very acid, was not known. When this fact did become known, liming was in many cases resorted to as a cure for poor and deteriorated areas, and in some cases good results were reported.

As analytical methods improved and a mass of reliable data on soil acidity began to accumulate it was realised that not only was lime proving of little or no use, but that there were many instances of failure to establish good tea on soils low in acidity. The causes of low acidity are :—

(1) The comparative "newness" of the soil.

Alluvial soils of recent deposition may contain large quantities of bases. The first attempt to plant tea in Assam was on a river bank or "chur", near Sadiya. The failure of the attempt might well have been due, in part at any rate, to the low acidity of the soil.

(2) Flooding by water containing bases.

Such soils are common in parts of the Dooars, and attempts to establish good tea on these areas have met with failure, until suitable measures have been taken to increase the soil acidity. In the Surma Valley also, floods in 1929 resulted in the deposition of neutral or alkaline silt.

(3) The burning of large quantities of wood or other vegetable matter on the soil.

Sites used previously by charcoal burners or occupied by villages, are commonly low in acidity due to bases introduced into the soil in the form of wood ash etc.

It has sometimes been the practice in clearing forest before planting up a new area of tea, to collect the vegetation into huge piles for burning. The soil of such areas has often been sent to us for examination on account of failure of tea to grow, and is invariably low in acidity.

(4) Application in previous years, of large quantities of lime or other alkaline manures.

Very large applications of lime have been made, on very light soil, at Tocklai, and have caused serious harm to young replanted tea.

It is very possible that low soil acidity resulting from heavy liming in previous years, has been the cause of poor results in replanted tea.

(5) Continued application of large doses of bulk organic manures such as cattle manure.

It might be thought from what has been said previously, that bulk organic matter would increase acidity, but in cultivated soils it is not so, since the organic matter is decomposed by soil cultivation and aeration; and residues of bases are left behind.

The following figures show the result of application of cattle manure on Borbhetta soil. 10 tons of manure had been applied annually for 6 years when these results were obtained.

Treatment.	Soil acidity pH.
No manure	5·4
10 tons cattle manure annually since 1931	5·7

The effect on soil acidity of 20 tons compost annually for two years is as follows :—

	Soil acidity.
	pH
No manure	5·8
40 tons compost	6·0

These differences are as yet certainly not sufficient to produce any harmful effect on mature tea. In time, however, the cumulative effect of continuous applications might render the soil unfit for young tea

Composts in which wood ash, Adco, or calcium cyanamide has been used, are of course more liable to reduce soil acidity than those in which none of these alkaline materials have been used in their preparation.

Since 1921 experiments on the effect of lime and other alkaline manures on growth of tea have been made and the evidence may be summed up as follows :

(1) Tea established on acid soils does not suffer, nor does it benefit, from application of small or moderate quantities of lime or other alkaline manures.

(2) Established tea shows only slight bad effects from heavy lime application, sufficient to bring the soil to a very low acidity.

(3) Heavy applications of neutral potash salts also have little effect but tea suffers extremely from heavy doses of salts of soda.

The bad effect of soda is due mainly to its bad effect on tilth, a combination of clay and soda resulting in a sticky complex which renders the soil cheesy and impermeable.

(4) Attempts to establish young tea on soils very low in acidity almost always fail.

The following table shows the effect on soil acidity of various manures.

Manure.	Effect on soil acidity.
Lime Calcium cyanamide Basic phosphate	decrease
Superphosphate Nitrate of soda Nitrate of potash	slight decrease
Sulphate of potash	no effect
Sulphate of ammonia	increase
Sulphur	large increase
Oilcake	slight increase
Green crops	no effect
Animal residues Cattle manure Compost	slight decrease

Treatment of under-acid soils.—The most effective treatment for soils on which tea is known to be suffering from under-acidity, is sulphur. This treatment is admittedly expensive, but it must be borne in mind that once sufficient sulphur has been added to correct the soil acidity, there is no advantage to be gained from further addition.

We have a laboratory test which gives us a rough estimate of the quantity of sulphur required for correcting the acidity of any soil.

The action of the sulphur in an under-acid soil is simply explained. With the help of certain types of soil micro-organism sulphur is converted into sulphuric acid, which is amply strong enough to detach the bases from the weak clay and organic acids.

The resulting salts—i. e. sulphates of soda, lime, potash or magnesia, are subsequently leached out of the soil. Thus the clay and organic acid complexes resume their acid condition.

Sulphate of ammonia has a similar effect; when the ammonia has been converted to nitrate and absorbed by the plant, the residue of free sulphuric acid left combines with and removes the bases from the soil.

Fears have been expressed that long continued application of acid manures might gradually increase the acidity of the soil to a degree harmful to tea At Tocklai and Borbhetta, by applying huge doses of sulphur, we have made the soil more acid than is ever met with in soil under natural conditions and no harm has as yet resulted. At Tocklai one dose of 40 mds. sulphur per acre was applied in 1933, and the soil attained a pH of 3·2. The yield of tea from these plots has since remained as high as the untreated plots, and actually went ahead in 1937.

We are not afraid of the effect on soil acidity itself, so much as the possible effect which acid manures may have in removing soil bases. There is the possibility that a soil very low in bases may in time become so "base free" after continuous manuring with sulphate of ammonia only, that the tea bush may show signs of disease due to lack of potash, lime or some other base. Every plant needs such bases, though in the case of many plants, requirements are extremely small. The following table shows the quantities of lime and potash taken out of the soil annually by various crops.

Crop.	Annual yield.	Lbs. per acre removed annually.	
		potash.	lime.
cotton	1½ tons	70	88
clover	2 tons	83	90
turnips	17 tons	149	74
wheat	30 bushels	28	9
potato	6 tons	76	4
sugar beet	20 tons	310	35
tea	1/3 ton	19	4
tobacco	1/3 ton	50	60

The amount of soda or magnesia removed is in general very much smaller than that of lime or potash. Tea removes annually not more than one or two lbs. soda, and not more than 5 lbs. magnesia.

Most tea soils in general contain sufficient bases to supply the needs of the tea bush for many years. Thus the average available potash in our Borbhetta soil is about 0·016% or 640 lbs. in the top foot over one acre. The figure for available lime is about the same. Even if none of the much larger amount of potash and

lime regarded as not available, never became available, the available supply of potash should last average tea for 32 years, and the lime for 150 years. Thus, while we may in time need to replace potash artificially, it would appear that there is little fear of the tea bush suffering from lime deficiency, under normal conditions.

Tea at Borbhetta manured for seven years with sulphate of ammonia only, shows no sign of suffering which could be attributed to soil base deficiency, and we have every reason to believe that with normal annual doses of this manure it would take a long time to deplete the soil bases seriously.

To avoid the risk of doing so however, it is our policy, in the case of very acid soils known to be already low in bases, to advise the application of calcium cyanmide at intervals to replenish the soil's lime content, and where potash is markedly deficient, to recommend the occasional application of a potash manure. There is certainly little to be feared from continued use of sulphate of ammonia alone for long periods, on most tea soils.

There is some evidence to show that many soils which we have hitherto considered sufficiently acid for tea, would respond to treatment making them still more acid. Poor tea growing on a stiff soil with a pH about 5.5 has shown very good response to sulphate of ammonia, and also to sulphur. I quote the results of one year's trial as being of particular interest as this experiment is the only definite one we have on a soil of this character.

Manure.	Mds. tea per acre in 1937.	Soil acidity pH.
Nil	3·48	5·45
Sulphate of ammonia 400 lbs. per acre	4·97	5·32
Sulphur 800 lbs. per acre	4·32	5·07
Mixture of 800 lbs. Sulphur and 400 lbs. Sulphate of ammonia per acre	5·66	4·98

It is very likely that there are many gardens containing areas with soils whose acidity is slightly but not particularly low for the soil type, where increased soil acidity would result in great improvement in the tea. In the present state of our knowledge however, more experiments are necessary before definite advice can be given.

With regard to the effect of soil acidity on quality, we know little or nothing. A good effect on quality from addition of sulphur to the soil has been claimed on a Darjeeling garden, but the evidence is not definite. Tea was manufactured at intervals throughout the year from a sulphured section and from one not sulphured. The tea from the sulphured section had definitely more flavour, but this difference may have been inherent in the jat or soil, or due to some other factor quite unconnected with the sulphur treatment. This year we hope to obtain information on the effect of heavy lime and heavy sulphur dressings on quality. For this purpose we are manufacturing leaf from 9 plots which have had 50 mds. lime in 1937, and 9 plots which had 32 mds. sulphur. The teas will be compared with teas made from 9 plots of the same age and jat which have had no lime or sulphur. The soil of the limed plots is nearly neutral, that of the sulphured plots is extremely high in acidity (higher than is ever met with in any type of soil in nature), while the untreated plots have a normal acidity for soils of this district. The information we hope to obtain from this experiment should be a valuable contribution to our knowledge of the effect of cultural conditions on the quality of tea."

DISCUSSION.

The Chairman referred to another cause of low acidity of soils caused by white ants. White ant teelas were generally alkaline and the soil from these teelas spread over the surrounding soil might reduce its acidity considerably. He also referred to the fact that old tea in quite good condition was growing on neutral or alkaline soil in Dehra Dun. Its yield however was very low and its quality very different from that of tea grown on acid soils of North East India.

Mr. Graham referred to the fact that whereas a surface soil might be low in acidity, the subsoil might be sufficiently acid for tea. This might account for the failure of young plants put out in replanting old tea areas; whereas the mature tea

previously growing on the land, and having roots in the acid subsoil, might therefore not have been affected by the surface layer of soil.

Mr. McLennan referred to the fact that sugarcane grows in many places in Assam on what are apparently acid soils whereas the optimum soil acidity for growth was shown to be about 7·0 pH, in the case of this plant.

The Chairman pointed out that though a crop might grow best on a pH of 7·0 it might still grow quite well in a much more acid soil.

In answer to a question by Mr. Boyle on treatment of village sites, Mr. Cooper said that in some of these sites the trouble was due to loss of physical condition of the soil consequent on the introduction of large quantities of soda, and that very often treatment of such sites was too expensive to make it worth while increasing their acidity to a degree suitable for tea.

Mr. Benton also referred to the fact that absence of soil bacteria on these sites might in some cases be responsible for poor growth of tea

The Chairman said that it was no good guessing at the amount of sulphur required for treating village sites and other areas low in acidity. The most satisfactory method was to send samples to this Department in order that they could be tested and advice given as a result of these tests.

RECENT ADVANCES IN THE CLASSIFICATION AND SELECTION OF TEA.

The Chairman called upon Dr. Wight to address the meeting on the subject of "Recent advances in the classification and selection of tea".

Dr. Wight addressed the meeting as follows :—

"I will begin by giving you a recapitulation of what I said last year, at the First Annual Conference, on the subject of "jat" and selection.

Selection followed by vegetative propagation could establish baries which will give

(1) Considerably more uniform progeny

(2) Progeny which will, in the mass, reproduce previously selected characteristics.

Some plants easily set seed with their own pollen—others require pollen from some other plant although there may be little or no superficial difference between the two plants.

In many species pollen is required from some other plant, but species in which the individuals show all manner of intermediates between self-sterility and self fertility, are common. Thus individuals are found which will set a certain amount of seed from their own pollen, others are quite self-sterile; some will do better with any other pollen, others require a particular pollen. Tea belongs to this class showing all manner of degrees of compatibility, but it seems safe to make the general statement that it is rarely satisfactorily self-pollinated.

We found that 7% seed set naturally, while over 30% resulted from the average of all manner of artificial crosses. After completing this work we turned up some Russian results in which they find that 8% seed set naturally.

All the characters of a plant or animal are reshuffled as independent units at fertilisation so that all possible recombinations of characters may occur in the progeny—this accounts for the variation in the tea plant.

A bari of 1000 trees is a bari of 1000 separate individuals very few of them being quite alike—the seed as sold is therefore the bulk of much more than 1000 different mixtures.

By making the bari a clone of 1000 vegetative individuals the mixture is reduced to one only, but the clone must be self fertilised and hence will probably not be satisfactory. We can however, find by experiment a suitable mate for it, and thus reduce the hybridisation in the bari from all possible combinations of 1000 to all possible combinations of two.

Hence the study of interfertility becomes of great importance.

Interfertility can be studied :—

(1) By isolating combinations of clonal material in the jungle—this consumes a lot of land.

(2) By artificial pollination—this necessitates a highly trained staff of some size, and a lot of supervision.

It seems likely that this latter method can be developed so as to save a good deal of land in the final tests.

It also seems likely that Laboratory tests can be devised which will eliminate a good number of the necessary pollinations, so that a combination of all three methods will be most efficient.

The Laboratory method referred to is based upon our hopes of correlating germination of pollen on the stigma with the set of seed in a similar cross.

In 1932 we discovered that two strains of bushes might be isolated which differed very markedly in the time taken to come away after pruning. Subsequent study showed that this difference in rate of growth was associated with a considerable difference in the structure of the frame of the bush, which we described (from the density of the branches left on a unit surface after pruning) as "open frame" and "close frame". It was also found that when left to grow unpruned and unplucked the natural growth of the shoots was different.

Open frame	Close frame
Runs to stout leaders	Twiggy bush
Comes away late	Comes away early.

Observations in every subsequent year have confirmed these differences.

It is now necessary to digress a little. Of recent years we have developed a method of examining the branch system of the bush : this involves taking a bush at the end of its first year after clean pruning, and counting the number of each order of branches

1st. order
2nd. „
3rd. „
—and so on

The frame of the bush left after pruning consists of branches and sticks ; we now find that our open frame bushes of 1932 when plucked make branches of a higher order, and more branches.

As a result of our manufacturing experiments we took by a method of randomisation, *and without seeing the bushes involved*, six bushes of high quality and six of low quality, all the bushes being comparable one with the other, and found that high quality went with a low order of branching and also with a lesser number of branches.

Furthermore, it was found that crop was also related to the branch system of the bush—the branch system which goes with high crop is the branch system which goes with low quality.

Generally, on the preliminary judgment of these samples, high crop goes with low quality and *vice-versa*. And each of these goes with a definite kind of branch system. Thus an extensive preliminary selection on the basis of crop is likely to eliminate many valuable plants. It is here that we disagree with the methods of selection being practiced in Java and Ceylon, and until Dr. Tubbs and myself can settle these differences you had better take what I am saying with some reserve.

In plant selection it is the odd bush here and there that one goes for—the value of plant selection depends upon one's ability to pick out likely exceptions, and in this averages and generalised statements or indeed any rule of thumb, do not count for much.

Now, as far as we have gone, we find that selection for the higher range of quality gives more bushes than selection for the higher range of crop, and bearing in mind what I have said about selection one would seem more likely to hit off the happy combination of crop and quality by selecting first for quality.

Quality seems to be a heritable character which may be generally associated with certain characteristics in a particular population of bushes of a particular kind. But quality may at times, if one looks hard enough, be found associated with almost any character. For example we have found extremely dark leaf bushes of vigorous growth and high yield which give quality remarked upon by the taster—and amongst the same stock of bushes, light leaf plants picked out by a scientific officer as desirable which were noted by the taster as being particularly bad.

In 1934, we surveyed the Tocklai plots for a certain leaf character X. Bushes showing character X were marked on our plans. In 1936 we shook up numbers representing all the X bushes and took out four; in a similar manner we took four non-X bushes. The two sets were manufactured separately and we found a much higher quality of tea associated with X.

We repeated these observations on the same bushes in 1937 and again found differences in the same direction. Thus the difference must be independent of season and in this particular stock, quality tea is associated with a particular morphological factor X.

A further check on selection in this stock was made in 1937. I picked out of the X bushes, five which I thought would give quality above average of the section. All the X bushes were eliminated from plucking; the non-X bushes were plucked separately, the leaf bulked and five samples taken out for manufacture—this representing the section minus the bushes supposed to be above average. Results again showed a correlation of quality, as judged by the taster, and the morphological factor X.

We believe that character X is a hybrid character which crops up in certain dark x light leaf crosses.

We accordingly turned our attention to another stock which we believe has been previously crossed, followed by rather careful selection, and found that

practically all the bushes in this stock showed the X character in some degree so that we were unable to make any reasonable division into X and non-X type bushes. It is interesting to note that we had previously found that this stock had a high level of quality.

We therefore plotted the frequency distribution for quality for such bushes as we examined and found that this gave evidence of the stock being composed of at least two and possibly three distinct strains of tea, thus giving pretty fair evidence of a previous and certainly successful cross.

We also turned our attention to the *smell* of the leaf; we had noticed that different kinds of smell were associated with green leaf.

We decided upon a smell which we thought desirable, and examined the leaf daily in regard to this "aroma".

Results proved that :—

(1) A difference in smell exists between different bushes

(2) The difference in smell is associated with a difference in quality.

The conclusion is that quality depends upon the presence of an aromatic substance in the leaf.

In 1934 we examined samples of tea flowers from all over India, determining the number of stamens per flower, and from this plotted a frequency distribution, *i. e.* number of flowers with 20 stamens, number with 30 stamens, and so on.

We find that the frequency distribution gave a regular curve, from which we conclude that in point of stamen number—which is an important character—all tea in cultivation belongs to one species.

The calyx is another important character, and we find this to be very constant in all tea. In selection concerned with differences within the species, however, very significant differences are found in the number of stamens between different bushes, and hence between collections of similar bushes. This however is not the only difference and my assistant finds that the variation between flowers is as great or even greater than that between any of the other characters of the bush, and that in some cases floral differences are much more marked than differences in the leaf.

He has noticed, besides known differences in stamen number, statistically significant differences in the number of petals, differences in the physiology and structure of the stamens, and differences in the structure of the style and stigma.

It is not yet certain how much taxonomic value we can attach to these differences but they are certainly of great importance in selection, genetical work, for classification of tea in clutivation, and possiby for the investigation of geographical races of tea growing in different localities.

Cohen Stuart in Java, and Sir George Watt, have previously attempted classifications of tea but confined themselves to vegetative characters, mainly those of the leaves.

It is an axiom in Botany that classification must be based upon floral differences, so that the potential value of these recent discoveries will be evident. So far as we know they have not previously been recorded.

In order to prove our case and to establish a claim we have confined ourselves to the structure of the stigma—perhaps the most conservative organ of the plant—in a few selected examples. The following series of lantern slides will illustrate clearly the differences in structure of stigma which have been observed by my assistant, to whom all the credit is due for this valuable piece of work."

(A series of lantern slides were then shown and explained by Dr. Wight).

DISCUSSION.

The Chairman said that he was sure that all delegates would appreciate the progress which was being made on the lines indicated by Dr. Wight in his lecture. They could hope for even more rapid progress in the future but he stressed the fact that the work done was not yet fit for publication.

Mr. Smart raised two questions—

(1) Does the parent tree gradually change the shape and size of its foliage as deterioration sets in, or do the only indications come from the seedlings of such a tree ?

(2) At what age would deterioration be likely to set in, given reasonable farming and no possible chance of contamination from other trees of doubtful origin ?

Dr. Wight said that at one time he had thought that deterioration of jat in seedbaries was a myth and he also thought that this view was held in Ceylon, but he now was inclined to believe that there was possibly something in this question of deterioration. It was difficult to say why, but there was the possibility of dimorphism and its connection with possible changes in the seed at some stage during the life cycle of the seedtree.

Mr. Fegan asked whether the production of small seed could be associated with less vigour in the seed tree.

Dr. Wight said that this was so. He thought that the progeny from small seed should generally bear the same characters as that of the previously larger seed from the same tree and that the size of the seed should increase after the vigour of the trees had been restored by suitable treatment.

He added also that it was a possibility that the less vigourous plants in a seed garden might be those with better quality. If these less vigorous plant die out first, the genotal character of the produce of the seedbari would naturally change accordingly.

PROCEEDINGS OF A MEETING HELD ON SATURDAY, 19TH FEBRUARY 1938 AT 9-0 A.M. AT THE TOCKLAI EXPERIMENTAL STATION.

DISEASES AFFECTING THE WOODY PORTIONS OF THE TEA BUSH.

The Chairman called upon Mr. Tunstall to address the meeting on the subject of "Diseases affecting the woody portions of the tea bush".

Mr. Tunstall addressed the meeting as follows.

"Every planter is familiar with the decay of tea branches, and there are few sections on which there is not a fairly large percentage of such branches. Reduction of crop per acre to an uneconomic level is largely associated with the decay of the frames of the bushes on the areas concerned. During my earliest tours in the plains tea districts especially during my first visits to the Surma Valley, I noticed the enormous losses being caused by such decay. Most of the planters concerned seemed to consider these losses as the natural and unavoidable result of heavy pruning. Some were trying to avoid some of the losses by painting the larger cuts with Stockholm tar. At first it was generally assumed that the death and decay of the branches was solely due to the infection of the exposed wood by microorganisms. Further examination however has shown that the death of portions of the frame frequently occurs before the wood becomes seriously infected by any organisms. The portions of the branches which have died back usually become infected by fungi in the second year after pruning. Among the earliest and commonest invaders of the dead tissues are *Diplodia sp.*, *Glomerella major* and *Fusarium sp.* Any or all of these may attack the living tissues adjoining the dead ones. Thus the dead portion is gradually increased. About the end of the second season a second group of fungi e.g. *Poria hypobrunnea* invade the dead tissues. These fungi do not kill living tissues but decay the wood already dead. In most cases the decayed wood is then eaten by white ants. This kind of thing goes on in the dead snags on vigorous bushes as well as in those in poor condition. In the case of vigorous bushes however the progress made by the parasitic fungi is slow.

The problem of reducing the losses caused by the decay of the woody tissues may be divided up into three parts.

1. The prevention of die back following pruning.
2. The treatment of uninfected wounds.
3. Treatment to arrest decay in wounds already infected.

Prevention of die back.

It is important to observe the conditions under which the dying back of branches after pruning is most prevalent.

Age of wood and position of the cut.

It has been found that the older wood has a greater tendency to die back. It was also noticed that branches originating in the centres died back more readily than those growing up from the outside of the frames. The presence of a young branch adjoining a cut tended to prevent dying back but if the young branch was some distance below the cut the old wood frequently died back to the young branch concerned.

Type of cut.

It was noticed that the best results were obtained when the cut was made at an angle to the axis of the stem concerned. Cuts made with a saw heal more readily if smoothed with a sharp knife. In the case of very large cuts, the rounding off of the edges seems to aid the formation of a smooth, even, callus over the wound.

Climatic influences.

It was observed that, in districts where the air in the cold weather was dryer, e.g. parts of the Surma Valley, the amount of die back following pruning tended to be greater. It was also noticed that the portions of a garden where the air was damper e.g. along jungle edges in narrow areas between small hills, the tendency to die back after pruning was less than in the more open parts exposed to dry winds. The die back after pruning in the Darjeeling district was noticeably less than in the plains districts, and it was at one time assumed that this was probably associated with the dampness of the air. It is more probably due to the higher level of starch reserves.

Jat of the bush.

The influence of jat was also apparent. The China and Burma types of plant did not seem to suffer so badly as the light leafed types. Differences between bushes of the same general type were noticed later. Bushes with a free growing habit seemed to die back after heavy pruning more readily than stunted ones. This was at first attributed to differences in the hardness of the wood.

Starch reserves.

Owing to the tendency for frames to die back after heavy pruning many planters preferred to collar prune the bushes and build up an entirely new frame on the old stumps. This operation was almost invariably followed by a larger percentage of deaths. Examination of the dead plants showed that in many cases their death could not be attributed to the attacks of parasites. It was also found that the dead plants had no starch reserves in their roots while the living ones usually had plenty.

Nothing can move or grow without energy. In green plants the energy is absorbed from light through the green portions of the plant. The light is used to bind together carbon dioxide and water to form carbohydrates such as sugar, starch etc. A large percentage of the weight of roots of a vigorous tea bush is starch. It would seem therefore that the starch in the roots may be taken to be a criterion of the energy reserves of the tea plant. The results of our observations suggest that this assumption is correct. Although there are other substances present which can be broken down readily to provide energy it is probable that starch is the principal energy reserve in the tea plant.

As early as 1916, a simple starch test was applied to tea roots. Starch is turned dark blue by iodine. By dipping the cut end of a tea root into a weak solution of iodine, it is possible to obtain a rough estimate of the starch present by the degree of darkening produced in the wood. This test was admirably suited to casual field observations but it seemed to be too indefinite for precise estimations. An attempt was made to find a method of chemical estimation which could be carried out satisfactorily by the staff available. We have not yet found a test of this nature which can be applied to the large numbers of roots required to obtain statistically valid estimations of the differences in starch content associated with the

various cultural operations. We therefore had to fall back on the iodine test. In 1929 we worked out a technique for making further use of this test. We could not say whether it was good enough until we had collected a large number of observations. We wanted to know what factors affected the amount of starch reserves in the roots of tea bushes. We could then observe how those factors affected the amount of stem disease on the bushes concerned. In interpreting our results we had the help of Mr. S. S. Bose of the statistical laboratory of the Presidency College of Calcutta University. His assistance has been most valuable. So far we have been able to draw the following conclusions.

1. When the bush is flushing vigorously the reserves of starch are reduced temporarily. There is a tendency for starch reserves to increase during periods of slow growth. In healthy young plants, up to four years old, the starch reserves may fall to a very low level during a period of rapid growth and rise to a very high one during a period of slow growth.
2. The average level of starch reserves is lowest during the early part of the growing season and increases as the season advances. It reaches its maximum at the end of the growing season.
3. The general level of starch reserves is positively correlated with the yield during the period August and September. Thus a higher starch level is associated with a higher yield of leaf during that period.
4. The influence of manurial treatment on starch reserves is sometimes significant but too small to be of great importance.
5. The starch reserves were found to be significantly lower in bushes which had been collar pruned seven years previously than in those which had been medium pruned (to18″ from ground) at the same time.

Some of the above conclusions may require modification. The observations were made on bushes with a fairly high starch level and it is possible that in the case of bushes with lower starch levels the influence of cultural environment, such as manuring, may be more pronounced.

Our own conclusions have received considerable support from observations made on tea in Ceylon. At the Tea Research Institute, Gadd found, in 1928, that the roots of bushes which had died after pruning were destitute of starch reserves

whereas the latter were present in the roots of healthy bushes and of those which had died as a result of infection by root disease fungi. He concluded that *Botryodiplodia theabromae* present on the roots of bushes that had died after pruning was secondary, the primary cause of death being lack of sufficient starch reserves in the roots to enable recovery when the bush was pruned. More recently Tubbs, at the same institute, has been investigating the question of carbohydrate deficiency in relation to die back after pruning. He discovered that the carbohydrate reserves in tea bushes were higher at higher elevations. The tendency to die back after pruning was less at higher elevations than at the low ones. He also found that rapid growth prior to pruning increased the amount of die back. He demonstrated that the method of pruning affected the carbohydrate level in the roots in spite of a wide divergence in the amount of new growth produced.

The importance of having ample starch reserves in the bushes at the time of pruning in North East India is most obvious in the case of young plants. It is not unusual for such plants to die soon after pruning. Examination of some thousands of dead plants from all the districts in North East India has shown that in most cases there are no starch reserves present in the roots. If all the green portions of the plant are removed it has no means of absorbing more energy from the light. It must rely on its reserves of energy. If the energy reserves are absent such a plant must die. If the energy reserves are unduly low, portions of the plant may die back because there is insufficient energy to support all the new growth until the latter is able to absorb sufficient for its requirements. In large bushes there is a larger storage capacity than in small ones and the fluctuations associated with flushing are in consequence much less marked. The general level of the reserves in the larger bushes is however of importance. We have not ascertained the critical level below which die back is likely to occur. There are so many modifying factors that it is doubtful whether there is a definite critical level. There is however no doubt that the severe pruning of bushes with little starch reserve is followed by more die back. It is therefore important to ensure that starch reserves are ample before severe pruning is carried out.

Methods of ensuring ample starch reserves before severe pruning.

As the leaves are principally concerned in the absorption of energy it is obvious that the more leaf there is on the plant the more energy is likely to be absorbed.

The problem is therefore to find the best way to obtain the maximum effective leaf area on the bushes concerned. At first sight it would appear that this would follow were the bushes left entirely unplucked for the season preceding the severe pruning. Experience however shows that in some cases the bushes produce very little growth after the initial flush. This more frequently happens in the case of plants in a very poor condition. Observations on a few individual bushes at Tocklai suggest that the initial flush uses up a large amount of the reserves in its growth and does not begin to pay back until it has ceased growing. There is less reduction in reserves if the tops of the young shoots of this flush are plucked. If most of the older leaves produced in this flush are removed by Red spider or other agency before they have had time to make up the reserve they have used there may be insufficient energy available to enable the bush to make any further growth and die back occurs. On very poor bushes it is probably better to prevent the undue loss of reserves in the beginning of the season by plucking to three leaves from the janum during the first and second flush and then allowing the bushes to remain unplucked until the end of the season. In the case of tea in a fairly good condition plucking may be suspended for at least one complete flush period before the pruning is carried out. Care should be taken to avoid pruning at the end of a period of very rapid growth as at that time the reserves are likely to be at a lower level. It is better to wait until the end of a period of minimal growth before pruning. This is particularly important when cutting back young plants during the growing season. As the young plants do not all become banjhi at the same time it is necessary to spread out the time of the operation. Individual plants should be pruned when the banjhi buds are beginning to swell.

Influence of manuring.

It should be understood clearly that the bushes do not obtain their supplies of energy from the soil and no direct increase in energy reserves is likely to result from manurial applications. Indirectly, however, manuring may help by increasing the effective leaf area, provided that all the extra leaf induced by the manuring is not plucked off. Manures may therefore be advantageous if applied some time before the pruning is done, thus enabling the bushes to take advantage of the additional energy absorbing area. The policy of applying manures at the time of severe pruning has little to recommend it.

The treatment of uninfected wounds.

When the protecting bark is removed and the wood is exposed, the danger of infection by parasites is much increased. Infection does not however take place so readily as we at one time supposed. Our observations show that serious infection is not usual until the wood has been exposed for a whole season. There are exceptions which will be mentioned later. The natural method of protecting a wound is by covering it with callus. The callus originates from the growing layer between the bark and the wood. Small cuts on one-year-old twigs generally callus right over in one season and serious infection is unusual. On such wood unsatisfactory healing is more frequently associated with the drying up of the exposed wood and the death of the neighbouring bark due to loss of water. This is particularly noticeable on areas exposed to dry winds. On such areas it may be worth while to protect these small wounds with a waterproof paint. On most areas however this is unnecessary. In the case of wounds on the older wood it usually takes more than one season for the callus to cover the wound completely. Infection by parasitic fungi is therefore much more common and some protection is called for. Our experiments have shown that tar is unsuitable for this purpose as it frequently checks the growth of callus. Various fungicidal applications such as Bordeaux or Burgundy paste have the same effect

Bitumen paint.

We have found that a paint made by melting 6 parts of hard (30/40) bitumen and mixing in 4 parts of cheap kerosene is very satisfactory. It not only protects the wound from infection but also encourages callus growth. Unfortunately the protection afforded does not last more than one season. This is not due to any defect in the paint but to the nature of the callus growth. A small portion of the wood in the neighbourhood of the bark whence the callus originates becomes exposed in the course of the growth. As the callus does not fit perfectly to the cut surface there is a place for organisms to enter the woody tissues. It is therefore desirable to repaint in the next cold weather all the wounds on old wood, which have not completely healed. Our experiments were made with Trinidad asphalt but there is no reason to suppose that bitumen from other sources will not be found just as good. However it is unwise to take anything for granted and we are trying

out a number of samples. Bitumen of a hardness of 30/40 seems to give a paint of about the right consistency when mixed with kerosene in the proportions given above. There are some very hard bitumens on the market which will not form a good mixture with kerosene. These should be avoided. Very soft bitumen requires less kerosine. As the kerosene is cheaper than bitumen it is better to get the harder bitumen. The paint should be stiff. If it is too thin it is likely to penetrate too deeply into the woody tissues and thus cause the bark to die back for a short distance.

However carefully heavy pruning is done, a certain amount of dying back always takes place. This dead wood requires to be cut out before decay commences. It is generally better to spend more money on the cleaning up in the year following the severe pruning. The larger cuts should be painted with bitumen paint in the first year. In the next cold weather those cuts which have not healed over should be repainted and any new cuts made in cleaning out wood which has died back should also be painted.

The influence of plucking on callus formation after severe pruning.

At the same time as experiments with wound paints were in progress, another series of observations were made to ascertain the effect of plucking on the healing of unpainted wounds. There seems to be an optimum height and type of plucking, and leaving heavy pruned tea entirely unplucked does not necessarily result in the quickest callus formation. Doubtless local conditions modify the optimum and it would be unwise to make a general recommendation as to height and type of plucking following severe pruning. Each case must be treated with due regard to local experience.

Treatment to arrest decay in infected wounds.

Although prevention is better than cure it is unfortunately necessary to seek for a cure as well. There are very few areas in which there are no rotting snags. The cutting out of all decaying wood is only possible where the decay has not been allowed to go very far. In comparatively few gardens has the pruning been done so carefully that there are very few decaying branches. In many of the older sections the removal of the decayed wood would necessitate collar pruning. In

many cases a hollow branch will continue to yield leaf for years, and if the progress of the decay could be arrested considerable loss could be avoided. So far we have not made much progress in this direction. The various fungicidal substances tried either failed to penetrate the rotting wood at all or if they did their fungicidal properties were neutralised by the substances in the tea wood. During my home leave I took the opportunity of consulting various scientists who are interested in similar problems and further experiments are now being made.

Removal of dead bushes.

It is safe to say that most of the casualties among tea bushes are caused by the decay of the frames following severe pruning. It is important for the planter to be able to distinguish between death from this cause and that caused by root diseases which are likely to spread from root to root below ground. Whenever a bush dies, whatever the cause, it should be dug out carefully so that as much of the root as possible is removed from the soil. If the roots show signs of disease special care should be taken to trace the diseased ones out, and should any be found to be in contact with the roots of a neighbouring bush the latter should be traced out also. If any signs of disease are present the bush concerned should be removed. Unfortunately on many gardens the frame of a dead bush is allowed to rot away and its position is often forgotten. Should the bush have been attacked by a dangerous root disease, the infill will ultimately become diseased from the infected wood left in the soil and in all probability the disease will also spread to neighbouring bushes.

Diseases not associated with debility.

There are certain fungi which occasionally attack vigorous tea branches. The dying back caused by such fungi is not associated with a deficiency of starch reserves in the roots. In cases where the dying back of branches does not appear to be associated with the snags left after heavy pruning, two small lateral roots should be cut off and the cut surfaces dipped in a weak solution of iodine. If they go black it may be assumed that there are ample starch reserves. In such cases a representative bush should be sent to Tocklai, as it is probable that the dying back has been caused by one of the fungi which attack vigorous branches. The com-

monest of these fungi is *Nectria cinnabarina.* The spores of this fungus infect the exposed wood on freshly made pruning cuts. This disease usually spreads from a centre of infection which may frequently be traced out and removed.

Summary.

Most of the death and decay of the frames of tea bushes is associated with debility following severe pruning. A great deal of loss can be prevented by ensuring that there are ample reserves of starch in the roots at the time of pruning.

The healing of wounds may be facilitated by waterproofing them with Bitumen paint and by the judicious plucking of the new growth.

Detailed recommendations in regard to the method employed to ensure ample starch reserves before pruning or to the height and type of plucking following pruning cannot be given. The methods must be related to the conditions on the sections concerned.

Further investigations are in progress to find a method that will check the further extension of death and decay in infected wounds. At the same time a substance is being sought that can be incorporated in the paint to prevent infection without checking callus growth."

DISCUSSION.

Mr. Cooper asked if Mr. Tunstall could state the time of the year when the starch reserves in the tea bush were at a maximum.

Mr. Tunstall replied that in general after the initial flush, starch reserves fell and thereafter rose until the end of the season. At Tocklai bushes were found to be at their maximum by the end of December and remained roughly at that level until the commencement of the next season's initial flush. This however might not apply in all tea districts.

Mr. Cooper asked if there was any great difference in starch reserves between, say the begining of November and the end of December.

Mr. Tunstall said that the difference would be very small on tea bushes in good condition, amounting to not more than about 10%.

Mr. Fegan asked whether starch content was much lower in October.

Mr. Tunstall said that it would certainly be less but it depended on whether the bush at that time was flushing vigorously or was at the end of a period of minimal growth. Normally there was sufficient starch reserve from towards the end of October onwards throughout the cold weather.

He also suggested that it would be advisable in the case of heavy pruning done in October to prune at the end of a banjhi period.

Mr. Allan asked whether in view of these observations there was any danger in early heavy pruning in the Dooars.

Mr. Tunstall replied that there was no danger providing the starch reserves were adequate at the time of heavy pruning. He suggested that the Manager himself could carry out a rough test to see whether the starch reserves were adequate.

Mr. Boyle asked about heavy pruning in March.

Mr. Tunstall said that there was nothing against it from the point of view of the starch reserves but care must be taken to do this heavy pruning before the bush commenced to flush. The starch reserves were still at a maximum in February or March.

Mr. Boyle asked about the method of starch production in the tea bush.

Mr. Tunstall explained that the bush absorbed carbon dioxide through its leaves and that this carbon-dioxide was combined with water drawn up from the roots, to form carbo hydrate e.g. starch under the influence of sunlight. Thus in the case of a bush which was suffering from inadequate starch reserves, these reserves might be increased by lighter plucking which left more leaves on the bush.

Mr. Mackay referred to the question of healing of pruning cuts after heavy pruning and asked whether pruning when the sap was free-flowing had given better results at Tocklai than at other times of the year.

Mr. Tunstall said that they had no experimental evidence on this point.

Mr. Smart referred to root disease on tea and to the fact that it was common knowledge that a certain number of bushes survived on bad root-diseased areas and showed no signs of attack.

He asked whether it would be feasible to use these survivors as seedbearers in the hope that they would be immune from disease.

Dr. Wight replied that the chances were more than likely that a big percentage of these bushes might prove to be immune or at any rate resistant to disease.

Three questions were then put by Mr. Smart—

(1) Is starring of tea seed caused only by the tea seed bug.

Mr. Tunstall replied in the affirmative.

(2) At what stage of the formation of the seed does starring take place.

Mr. Tunstall replied that it took place at any time during the growth of the fruit. In the case of a very early puncture, the seed would abort.

(3) When is the best time for treatment of seed-trees to prevent starring of the seed.

Mr. Tunstall said that in view of the fact that the tea seed bug would puncture the seed at any time during the season, there was no definite time either for spraying or for catching of the bug. Spraying had not been found to be of much use and it was better to employ a gang to catch and destroy the tea seed bug throughout the season.

ENZYMES, WITH SPECIAL REFERENCE TO TEA.

The Chairman then called upon Dr. Roberts to speak on the subject of "Enzymes, with special reference to tea".

Dr. Roberts addressed the meeting as follows—

"You have all seen that "fermentation" figures on this year's programme, and to justify this I am going to try to give you some idea of the chemistry of fermentation and to indicate the type of experiments we hope to carry out.

It must have occurred to all of you that the term fermentation is not restricted to the tea industry, in fact to most people the term is indelibly connected with beer, wines and spirits.

Alcoholic fermentation is caused by the action of yeasts on sugar. Bacteria can also bring about fermentation; to quote only two cases we have the fermentation of wine to give vinegar and the souring of milk.

Fermentation, as far as tea is concerned is rather a misnomer. The word is derived from the latin "fervere" to boil, for in alcoholic fermentation the rapid evolution of carbon dioxide was taken to be similar to boiling. There is no such boiling in fermentation of the tea leaf and etymologically speaking the term should be restricted to cases where there is a rapid evolution of carbon dioxide.

At first sight these fermentation processes seem rather mysterious but in reality they are no more so than the power we ourselves possess of living at the expense of the foodstuffs we take in. In each case complex substances such as proteins and sugars are broken down into simpler substances and the body, or the yeast cell as the case may be, either makes use of the energy set free in these decompositions, or utilises the simpler substances produced to build up its own bodily framework.

There seems to be a special property of living matter which enables it to bring about these far reaching chemical changes and in the early days of science it was usually ascribed to some vital force rather than to any particular chemical constituents of the cell. Actually the latter theory has proved to be the correct one, and to-day it is known that these changes are caused by enzymes. It has been found possible to obtain these enzymes, from both plant and animal sources,

in forms which are certainly not living. A German chemist named Buchner was able to obtain a dry powder from yeast which could ferment sugar to alcohol but which had none of the abilities of yeast to reproduce its species. Since the work of Buchner, many enzymes have been prepared in a "cell free form", that is to say devoid of life, and lately a dozen or more have been obtained as chemically pure substances even to the extent of being prepared in a crystalline form. To quote only one of these crystalline enzymes, there is pepsin, which as some of you may know, is responsible for the digestion of proteins in the stomach. I can speak with a certain amount of authority on this aspect of the subject as before coming out to Assam I was engaged on this type of work and I was successful enough to be the first to prepare one such enzyme in a pure crystalline form.

However to say that fermentations are the result of enzyme actions does not really give us a very satisfactory explanation of the fermentation process and our next enquiry is: "What is an enzyme?"

An enzyme is a particular form of a catalyst, and a catalyst is a substance which has the power of enormously accelerating a chemical reaction.

A solution of ordinary sugar will remain unchanged for a very long time even if it is boiled, but actually, speaking from the chemist's point of view, all organic substances with such complicated structures as sugar are really unstable substances. From a theoretical point of view these unstable substances must be decomposing but the actual rate at which they are decomposing is so very slow that in a lifetime the change would not be apparent. In a way the case is somewhat similar to that of a heavy weight resting at the top of a slope. There would be a greater degree of equilibrium if the weight would slide down to the bottom. Its tendency to do so is there, but this tendency is opposed by the frictional forces. Now if the frictional forces are removed or reduced by oiling the surface, the weight will slide down to its position of greatest stability. The action of a catalyst in a chemical reaction is not dissimilar; it promotes the attainment of equilibrium and yet it is unaffected in the process. Just as the amount of oil remains the same so a catalyst accelerates a chemical reaction without itself being consumed in the process. We can if we like consider a catalyst as a chemical lubricant but it would be unwise to push the analogy too far.

The action of catalysts is well known in chemistry and perhaps I had better give you an example. Finely divided metals, particularly platinum and palladium are very active catalysts. Amongst other reactions, they catalyse the oxidation of methyl alcohol. One has only to pass the vapour of the alcohol over the finely divided metal for the alcohol to burst into flame as a result of the energetic oxidation. On this principle a well known cigarette lighter has been put on the market.

The enzymes are the catalysts of the living cell and they have one or two very distinct properties which distinguish them from the catalysts of everyday chemisty.

Enzymes are very susceptible to high temperatures, and heating to a temperature of 160°F. or more is usually sufficient to destroy them more or less completely. This is of practical importance in manufacture as one purpose of firing is to arrest the chemical changes that have been occuring in the fermenting leaf by destroying the enzymes. Once the enzyme is destroyed, the action they are catalysing ceases. Enzymes are not just initiators of a reaction.

Another characteristic of enzymes is that they function best at one particular pH (Mr. Harrison is talking about pH). At pH's remote from this optimum, action may be slow or even non-existent. Now if you are fermenting on a floor contaminated with the dirty residues of a previous day's fermentation you will have bacterial action (which incidentally is also enzymic) with the probable formation of alkaline substances such as ammonia. These by affecting the pH of the tea juice will slow down *true* fermentation as well as introducing other disturbing factors in the quality.

A third characteristic of enzymes is that they are specific. An enzyme usually catalyses a change in one particular type of substance only. Consequently we have enzymes specific for proteins only, others that will act on one type of sugar and not on another, and others that may catalyse the oxidation of one particular substance only *e. g.* alcohol. Possibly the least specific of all are the plant oxidases and peroxidases and it is these enzymes with which we are especially concerned in the fermentation of the tea leaf.

Both plants and animals require large amounts of energy for their various vital processes and this energy is provided by the enzymic oxidations which take place in the respiration of the organism.

In the plant the most familiar manifestations of these respiratory phenomena are the exchanges of oxygen and carbon dioxide. Oxygen is taken up, oxidises the sugar, and carbon dioxide is produced. This is the reverse of the process in which carbohydrates are stored in the plant. Starch accumulates in the plant and when it is decomposed the energy provided by the sun in its synthesis is again liberated to be made use of by the plant in its own vital processes.

I am not going to attempt to explain the mechanism of these respiratory changes, as not only are they very complex, but also it is by no means certain that the biochemists themselves are as yet in a position to give a complete picture of what is going on. Let it suffice to say that in plant respiration the oxidases and peroxidases are intimately concerned and that the various oxidation and reduction processes are very delicately balanced. Now if the plant tissue is injured in any way this delicate balance is upset and oxygen has an easier access to the cell. Under these conditions some of the oxidations catalysed by the oxidases go too far and produce the familiar brown pigments, which you have all seen in cut apples and fermenting tea leaf. In the case of tea it is of course the tannin which gets oxidised.

You now are in a position to appreciate why the preliminary withering and rolling of the leaf are necessary before fermentation can take place. Fermentation, that is to say the production of brown pigments in the leaf, only takes place in those cells that are damaged. Incomplete rolling means that many of the cells remain undamaged and in those cells no fermentation will take place so that the finished tea will be partly "green".

Another point about fermentation is that, as you know, the best results are obtained by a thin spread on the fermenting floor. There are two reasons for this. The enzymic oxidation is a process accompanied by a considerable evolution of heat. If you have a thick spread the temperature will rise and high temperature fermentation does not lead to the production of quality teas. There is another possible objection to a thick spread. The presence of oxygen is essential for the

fermentation process and with a thick spread oxygen will not be so easily accessible to the lower layers as it should be and, as in the case of under-rolling, a green tea may result.

This possibility is of more practical importance if ball breaking is not done. If the balls of fermenting leaf are not broken up, oxygen cannot penetrate into the heart of the ball and at the end of the fermentation period the leaf will still be quite green.

So much for the theoretical aspect of the subject. How are we to make experiments on the fermentation of tea leaf which will give us information of practical value.

In enzymic oxidations it is possible to measure the rate and extent of the process by recording at regular intervals the amount of oxygen which has been taken up, and for this purpose a very elegant apparatus is available. I have had some years experience of work of this kind, in fact it is really impossible to do much useful or accurate work on oxidising enzymes without it.

Let us consider some of the experimental results we could hope to obtain using this technique.

(1) *Efficiency and optimum duration of rolling.*

As I have already stated, incomplete rolling shows up by incomplete oxidation during fermentation. For the same amount of rolled leaf, the total amount of oxygen taken up, and of course the rate at which it is taken up, will be less for incompletely rolled leaf than it will be for the properly rolled.

(2) *Optimum temperature of fermentation.*

You may have heard of the experiments made here which show that the quality of tea increases as the temperature of fermentation decreases. A possible and by no means unreasonable theory to account for this is that at higher temperatures other reactions come into play, possibly due to micro-organisms, or even non-enzymic. This, by affecting the nature of the substances in the leaf at the end of the fermentation, will obviously affect the quality.

By analysis of the figures obtained for oxygen consumption at various temperatures such a side reaction could be detected and the temperature established at which its effects first becomes apparent. This temperature would of course be the maximum permissible temperature for fermentation if teas free from this objectionable characteristic are required.

(3) *Varying degrees of wither.*

We are hoping to carry out experiments in correlating various degrees of wither with quality of the final manufactured tea. Here of course the final appeal must be to tea taster's valuations, but I think much valuable work of a preliminary nature could be done by measuring the rate of fermentation after varying degrees of withering.

It is an important point to remember that with this technique fermentation can be carried out under standard and reproducible conditions. The temperature can be controlled to a fraction of a degree and also no fluctuations in the market or dirty factory conditions can affect the results.

(4) *Correlation of respiratory activity of the leaf with quality.*

For many years now analyses have been carried out to assess the correlation, if any, between tannin and caffein contents of the leaf, and the quality of the manufactured tea. A factor which is at least as important in determining the chemical nature of the manufactured product is the activity of the respiratory enzymes of the fresh leaf. This I feel sure could be measured by this same apparatus. I think that you will agree that it would be at the least very useful to have some means of assessing the probable value of the final product by a simple measurement on the fresh leaf.

These are just four investigations that have suggested themselves to me as both practical propositions and likely to be of value when completed. The list is not meant to be exhaustive, you yourselves could probably think of others. All I want to emphasise is that working on these lines good results on fermentation should be obtainable without having to manufacture. At the moment the work we can do is limited by two factors, the amount we can manufacture and the amount the tasters can handle.

This does not exhaust the possible applications of enzyme chemistry to tea. Fermentation is the immediate problem in hand but as I stated at the outset there

are many other aspects of importance to us. I might end by saying that enzyme chemistry is a sort of connecting link between pure chemistry and biology and I foresee much useful collaboration on this line in the future between the chemical and the other branches on this station."

DISCUSSION.

Mr. Graham asked whether the Department had any evidence as to whether withering was a necessary process in tea manufacture.

Dr. Roberts referred to the fact that a definite chemical change had been shown to take place during withering. Mr. Harrison pointed out that tea made without withering had distinctly different liquor characteristics from tea made by withering, and Mr. Graham's question was one which could not, at present, be answered.

Mr. Graham referred to the fact that he had tried to ferment leaf packed in a closed bottle and found that little or no fermentation took place. This indicated the necessity for a plentiful supply of oxygen to the leaf during fermentation.

Mr. Benton referred to the fact that some of the delegates had a number of questions which they had been instructed by their districts to put before the Conference, and asked whether these questions should be brought up in a formal discussion.

The Chairman said that he would bear this in mind for future conferences but he pointed out that all questions which had been sent in from the districts in good time had already been placed on the Agenda.

Mr. Cooper pointed out that in the case of many of the questions, time was needed for the Officers to discuss them among themselves and to collect relevant information.

Mr. Burton explained that unless the questions he had brought with him could be formally discussed they could not appear in the Minutes of the Conference.

The Chairman suggested that if the districts would send their queries in to Tocklai, the Department would in many cases be able to furnish bulletins or memoranda on those questions for circulation in the district concerned.

PROGRAMME OF WORK FOR 1938.

The Chairman gave a brief outline of the 1938 Programe of Work of the Department, mentioning that it was already in the hands of the delegates and that they also had the 1937 Programe of Work with which to compare it.

The Chairman said.

"As in 1937 the Programe of Work for 1938 is divided into two main lines :—

I. Factors which affect the quality of tea,

II. Investigations having for their objective the improvement of the tea bush.

I. *Factors which affect the quality of tea*—

Under this heading come the many important problems which at the present time can be investigated only empirically.

In 1937 experiments were carried out to ascertain the effect of plucking and pruning upon the quality of the tea made. In 1938 it will be impossible to repeat the pruning experiment as this can only be done in alternate years.

The plucking experiment has been carried out during two consecutive years. It is not advisable to continue this experiment in a third consecutive year. It is thought better to select at random a year for a further replication. There are, however, other experiments which are logical extensions of these—the pruning experiment has shown the value of clean pruning but whether the extent to which this is done affects the quality is not known. An experiment to ascertain this will be made in 1938.

Under the conditions brought about by the tea restriction scheme efforts are made on gardens to increase the early and late tea crops, these being the more valuable portions. Enquiries are often made whether the application of manures at different times and the manner and time of pruning will effect the quality of tea. Since there is no data at present existing on this subject an experiment will be carried out this year to ascertain the comparative effect of manuring in the autumn as compared with a spring application upon the quality of the tea made.

Experiments both at Tocklai and St. Coombs have shown that there is no difference in the quality of the tea resulting from the use of organic or inorganic nitrogenous manures. Experiments have also shown that the inorganic manures give as good or better crop returns than the organic manures when supplying an equal quantity of nitrogen.

The inefficiency on the nitrogen basis of bulky organic manure such as cattle manure has also been shown. Recently much interest has been shown by the tea industry in another bulk manure namely vegetable compost.

Field experiments are now in progress to ascertain the effect of compost upon crop, and at the same time it is thought advisable to study the effect upon the quality of the tea made. This experiment will be carried out in 1938.

Soil acidity exercises control upon the tea crop but there is no data to show whether it exercises any influence upon the quality of the tea made. This is an important matter and one upon which knowledge is needed since manuring schemes may be much nfluenced by the results; when efforts to reduce cost of production are being made so strenuously by the industry, such knowledge may be of much importance. Some tea at Tocklai has now reached the stage that makes this experiment possible. A comparison will be made of tea of the same age and jat growing on plots, the soils of which have different acidities controlled by the use of lime and sulphur.

Past investigations have shown a relationship between fresh leaf analyses and field treatments and between field treatment and the character of the teas made, and to a minor extent between analytical data and tea character. It is hoped to establish still further this last relationship and for this pupose the green leaf used for the above mentioned experiments will be analysed.

Until a close correlation has been established between chemical analyses of tea leaf and tea character it will be impossible to give satisfactory advice to estates where controlled and replicated manufacturing experiments are impossible. The importance to be attached to this investigation cannot be easily over-estimated.

It has already been shown that the uncontrolled development of micro-organisms in a factory may have disastrous results upon the quality of the teal made. Certain crude effective means of control have been devised but it stil

remains to determine how and where infection takes place and to devise means if possible to prevent it, for instance a high infection may be found upon leaf coming to the rollers and it has been shown that under certain conditions leaf going to the withering house with a low bacterial count may leave it for the rollers with a very high bacterial development. An experiment this year will be made to study bacterial development on old and new withering cloth.

Under the same conditions of temperature, experiments have shown that rolled leaf fermented on cement or clean aluminum sheets has the same quality.

It is necessary to carry this investigation further and to ascertain the rate at which leaf fermenting on these different surfaces will cool or become heated since laboratory experiments have indicated that the temperature of the fermenting leaf can be an important factor in determining the quality of the tea made. Whilst this has been shown in laboratory experiments at the present time very little else concerning the fermentation is known. Last year some preliminary work was conducted in regard to the amount of oxygen absorbed by the leaf during fermentation. This work will be further developed during the year. It may be advisable to make it clear that this investigation is not intended to be of a fundamental nature but is an empirical study of tea fermentation. A survey of the moulds that develop on finished tea has been conducted so far as time and staff have permitted and will be continued in 1938. This investigation requires routine work involving the preparation of a large number of cultures and is limited by laboratory accommodation, equipment and staff. Steady progress is being made but time will be required before useful data will be obtained.

One cause that is responsible for the annual death of a very large number of tea bushes is the devolopment of pathological organisms on unhealed pruning cuts and dead snags. An investigation is now in progress to find out the effect upon callus development of different substances when applied to freshly made pruning cuts. The experiment has so far shown that a certain bitumen stimulates callus formation. The experiment must be continued.

The killing of organisms growing at the interface of live and dead wood at the bottom end of a dead snag is even more important from the point of view of the tea planter. So far no satisfactory method of doing this has been found.

Work will be continued during 1938 giving particular attention to some of the phenolic derivatives and methods of application.

Black rot (*corticium invisum*) can be controlled by spraying with 1% Burgundy mixture during the growing season whenever a bush is seen to be attacked by the disease. The success of this method depends very largely upon the supervision that can be given. During the height of the plucking season it is sometimes difficult to give the necessary attention and to provide the labour required. It is therefore very desirable to find a treatment that can be made effective when applied in the cold weather. So far no such treatment has been found. Experiments will be continued in 1938 using certain copper compounds.

That there is a relationship between the development of disease and the starch reserves of a bush seems evident. It is necessary now to elaborate the technique for starch determination. This will be studied during 1938.

II. *Investigations having for their objective the improvement of the tea bush.*

During 1937, the leaf from individual bushes belonging to the same jat were manufactured to find out whether there are any differences in the characters of the teas made as judged by tasters reports. Some 200 bushes have been examined. As yet there has been no time to work out the results of this experiment but it is evident from a very casual examination that differences do exist. Such manufacturing experiments of leaf from individual bushes will be continued during 1938.

The next step will be the formation of clones from selected bushes but before this can be done it is necessary to examine the different methods of vegetative propogation which suggest themselves as likely to be useful. During 1937, owing to limitation of staff it was impossible to give attention to the experiment for differentiating individual bushes and obtaining proficiency in the technique of vegetative propagation. During 1938, the acquisition of those qualitative factors that make for success in work of this kind and the development of manual dexterity by the staff will be of greater importance than the accumulation of statistical data, although the importance of this will not be overlooked. The work can be summarised under three headings :—

(1) The acquisition of skill and judgment by the staff.

(2) The formation of a nucleus staff of nurserymen or plant propagators

(3) The propagation of the tea plant to the extent of our abilities.

Progress of work under these headings will be determined mainly by items) and (2) and by financial considerations. Much importance is attached to this ork but it must be developed slowly. An important point in dealing with this ork is the communication of the results to receptive minds and there is no more tisfactory way of doing this than by pictorial illustration. The illustration of nall differences existing between individual tea bushes is a matter of considerable ifficulty and will involve the purchase of optical equipment for photographic work. n Assistant is being trained in this work and when satisfactory progress is made special non-recurrring grant will be necessary but this will not be in 1938.

Mr. Roberts has now arrived and has taken over his duties in the Chemical ranch. It will now be possible for touring to be resumed and every effort will made during 1938 to visit those gardens scattered throughout North East ndia that are carrying out field experiments in co-operation with us. Whilst isiting such gardens it is hoped that there will be an opportunity of visiting other ardens in the immediate neighbourhoods."

DISCUSSION.

Mr. Cooper mentioned the fact that in the experiments on the effect of bulk organic manures on quality of tea, the plots to be used were those which had been treated with cattle manure for seven years. The plots which had been manured vith compost were not being used at present in these experiments on quality because they had received compost for two years only, and it was not expected that ppreciable differences in quality would show up after so short a period of manuring.

Mr. Tunstall asked that he might place on record the help received by the Department from Prof. Engledow and Dr. Maskell in connection with starch nvestigation, and of the help which the Department was receiving from the Imperial Chemical Industries (India) Ltd., in connection with the supply of various substances to be used for treating diseased wounds on tea bushes.

Mr. Graham enquired whether an Entomologist had been appointed.

The Chairman replied that a suitable man had already been appointed and was at present working at Cambridge. It was expected that he would arrive in India at the end of this year.

Mr. Graham asked whether in the meantime the Department could give any advice on the treatment of bark-eating caterpillar.

The Chairman replied that the Department could if desired issue a note on the treatment of this pest. Other delegates agreed that such a note was required, and the Chairman said the matter would receive his attention.

Mr. Smart asked if the Department could carry out further and more extensive experiments on the use of cover crops in tea.

Mr. Cooper pointed out that there was at present no land available for the purpose as the Department had no sanction to plant out new areas. The experiment on the use of cover crops would certainly be done, if and when land was available.

The Chairman pointed out that it depended on permission being obtained to put out new extensions. This matter was still under consideration by the Government of India.

Mr. Graham made a formal suggestion that experiments should be carried out on the treatment of Thread blight in tea. The Chairman promised that the Department would take steps to do so, and Mr. Graham said that he would be very glad to give any assistance he could in this matter.

Mr. Smart said that experiments were required on the care and maintenance of shade trees particularly in connection with canker and other diseases of the sau tree.

The Chairman said that there was undoubtedly much information available from various tea estates and that it should be possible for this information to be collected together and issued in the form of a bulletin. He pointed out that experiments on shade trees were being carried out at Borbhetta and these he hoped would provide additional information.

Mr. McLennan said that it had been suggested to him that one of the Tocklai senior staff should be appointed to look after the comforts and arrangements for visitors while staying in the Guest House in the interests of the industry, and to enable them to see something of the district.

The Chairman promised that the attention of the Department would be given to this matter.

Mr. Burton asked what the policy of the Department was in regard to publications.

The Chairman replied that until recent years the Department had issued Quarterly Journals. This publication was discontinued partly owing to shortage of staff and to the fact that there was not always sufficient new material to warrant publication at definite intervals. The policy now approved by the Enquiry Commission was to publish annually a Report on the year's work and to issue bulletins, pamphlets or memoranda on subjects of particular interest and on aspects of the work of the Department which had reached a sufficiently complete stage.

Mr. Burton suggested that the pruning pamphlet issued some years ago by the Department, if brought up-to-date, would prove extremely useful. He also mentioned the book by Watt and Mann entitled "Pests and Blights of the tea plant" as being one which had proved very valuable but which was now out of print. The arrangement of publications so that they could conveniently be included in a loose leaf file, would be very useful, especially to young planters commencing their experience in tea.

Mr. Nicholls said he would like to endorse Mr. Burton's remarks particularly in reference to the pruning pamphlet by Dr. Hope and Mr. Carpenter entitled "Some Aspects of modern tea pruning" which might almost be said to have become a classic. Such information for instance as that concerned with the production of axillary and adventitious buds on the tea bush, was of the greatest importance from the practical point of view, in pruning.

The Chairman said that he and Mr. Cooper had discussed over a year ago the revision of the Pruning pamphlet referred to but they had come to the conclusion that there was not at present sufficient data to warrant publication of a revised edition. He mentioned that a new edition of "Indian Tea, its Culture and Manufacture" by Claud Bald, would shortly be published. This was being completely revised by Mr. Harrison in accordance with the present views of the Department and he thought that this would meet one of the needs referred to by Mr. Burton.

Dr. Wight suggested that a dictionary of planting terms such as was published in Java would be an excellent publication. It had the advantage that it could be easily revised when necessary. It was the general opinion of the delegates that a publication along such lines would be an excellent thing. The Chairman agreed and said the matter would have his attention. Mr. Burton said that such a publication would meet the case excellently.

Mr. Burton asked whether any investigations were going on or were projected on the keeping quality of tea and post-manufacture changes in general.

The Chairman referred to the investigations being carried out by Mr. Benton on moulds in tea.

The Chairman then asked the delegates whether they would express their formal approval of the Programme of Work for 1938. This was done.

FOREIGN MATTER IN TEA.

The Chairman brought up the next item on the Agenda namely that of Foreign matter in tea, and asked Mr. Harrison to address the meeting.

Mr. Harrison reminded the delegates that notes on the foreign matter in tea and on the occurrence of lead in tea had been issued from time to time by the Indian Tea Association in the form of Private and Confidential Circulars.

He mentioned that the Ceylon Tea Propaganda Board had issued a circular which was widely distributed in Ceylon to all tea producers and manufacturers, outlining precautionary measures to be taken for ensuring the purity of Ceylon teas.

He suggested that it would be desirable to combine the existing Indian Tea Association circulars dealing with the subject into one comprehensive pamphlet for circulation in North East India and said that a draft publication had already been compiled.

He then read out a summary of these recommendations for ensuring the purity of North East Indian teas and suggested that the delegates might have further suggestions or amendments to make.

Summary of recommendations for ensuring the purity of North East Indian Tea.

1. Impress on overseers and labour the vital importance of producing tea free from any extraneous matter.

2. See that the whole factory, including machinery, is thoroughly cleaned and iron work painted, before starting the season's manufacture.

3. Keep leaf and tea off the ground as far as possible, both before and after it enters the factory.

4. Sweep down racks and floors in withering houses daily before spreading the leaf; and the floors, walls and joists in the factory, daily before commencing manufacture.

5. Maintain machinery, floors and implements such as brushes and leaf baskets in good repair. Replace immediately baskets and brushes which become damaged.

6. Pick over leaf, if necessary by a staff specially deputed for the work :—

(a) Before withering or putting through the chaff or tobacco cutter.

(b) Before removing from the withering racks or chungs.

(c) When the leaf is passing in to the drier.

(d) Before sorting.

7. Provide receptacles for foreign matter at frequent intervals throughout withering houses and factory and teach the labour the habit of using them.

8. Forbid smoking, eating, *pan* chewing and drying of rice, in the factory and withering house.

9. Keep the repair shop entirely separate from the rest of the factory.

10. See that bins have close fitting lids and doors.

11. Sieve the tea immediately before packing and maintain the strictest supervision of this process.

12. Inspect tea boxes carefully before packing, and nail down the boxes immediately after packing.

13. Pack and sort in daylight.

14. Use only lead-free paint inside the factory and withering houses.

15. Avoid use of solder or any substance containing lead, on any surface with which tea comes into contact.

16. Use aluminium in preference to zinc or galvanised iron for trolleys, sifters, etc.

17. Lead-free linings of tea chests are preferable, but if lead linings are used, make certain that a paper liner separates the lead lining from the tea.

DISCUSSION.

Mr. Allan said that in many factories it was practically impossible to avoid the manufacture or packing of teas at night and that a suggestion might be included among the recommendations that in cases where night-packing or manufacture had to be done, flood lighting should be installed instead of having lights over the various machines, thus reducing the risk of insects, attracted by the light, falling into the tea.

Mr. Benton suggested that the colour of light and its effect in attracting insects was worth consideration. It was known that bluish "day-light" bulb attracted insects more than a yellow light.

The Chairman referred to the high percentage of iron rust found in collection of foreign matter from tea chests. This undoubtedly came from the iron structure in factories and withering houses. If iron work were well painted there would be little chance of contamination with iron rust. The paint used should be a lead-free as possible.

Mr. Allan asked whether aluminium paint was satifactory. The Chairman said that it was a very good form of paint for use in factories.

He also suggested that cement reinforcements around the lower parts of iron columns would help to eliminate rust from tea.

Mr. Nicholls thought that co-operation was needed from the Buyers, for instance that they should be asked to register details such as Number etc. of every chest in which foreign matter had been found so that when reporting cases of foreign matter occurring in tea it would be easier to track down sources of the trouble.

The Chairman asked whether it was the opinion of the delegates that the pamphlet on the elimination of foreign matter in tea should be published, because if so he would make recommendation to this effect to the Indian Tea Association, Calcutta.

It was agreed by the delegates that this recommendation be made but that the publication should be issued as "Private and Confidential".

BUD GRAFTING.

The Chairman referred to the next item on the Agenda namely *Bud grafting.*

Information had been requested on this subject from a district in Upper Assam. He called upon Dr. Wight to give such information as was available.

Dr. Wight said that since it was not until January 1938 that any regular investigations into the possibilities of vegetative propagation in tea had been commenced he had not very much information to give. He proposed however to deal with vegetative propagation generally. This included propagation from cuttings as well as bud grafting.

In regard to cuttings the methods used were as follows—

The cuttings were grown in a layer of sand over a layer of broken brick in order to provide adequate drainage. He thought that the sand would be better if it contained some organic matter. It was difficult however to control the amount of organic matter for experimental purposes. The material used consisted of cuttings from the red wood, making the cuts at internodes so that each piece of wood used for the cutting had one leaf.

They had found that both at Tocklai and in Ceylon it was better for the shoots on the branch to be banjhi at the time when the cutting was taken. He said that he preferred red wood cuttings but that Tunstall had had success previously with green cuttings. An English gardener's method is to use green cuttings, either true leaf cuttings being used or small banjhi twigs with a small heel of wood. English gardeners employed this method in making cuttings from other species of *Camellia.* Some bushes gave better results when used as a source of cuttings than did other bushes. Generally speaking bushes of the China type gave very good results, dark-leafed jats gave fairly good results while light-leafed Assam bushes frequently gave very poor results. There was however no definite information at present as to the best method of taking cuttings, the best method of treating them, or the best time of the year at which to take them.

Bud-grafting.—The method used was the patch method as used in making bud grafts from rubber plants, and it is now the only method of vegetative propagation used for tea in Java. The method was illustrated by diagrams on the black-board.

Dr. Wight said that it was often very difficult to find suitable dormant buds and that the same difficulty is being experienced in Ceylon. In Java however there did not appear to be this difficulty, and he concluded that conditions in Java resulted in a rather different type of bud development. Some trees give many and others very few, suitable buds. The percentage success in Java was reported to be very high—as high as 96%. With inexperienced labour the success obtained at Tocklai was only about 12—15 percent on average of a number of workers. It was during the period of August and September, that the bud-grafting was done.

It is uncertain at the moment which of the two methods of vegetative propagation will prove most satisfactory but even if the method by cutting becomes the general one it may still be necessary to bud graft from any selected bush from which cuttings cannot be made to root satisfactorily.

The kind of seed given by a graft will be independent of the root stock but the vigour of the whole plant will be definitely affected by the vigour of the stock so that a uniform root stock is desirable. The best method of obtaining this uniformity in root stock is by selecting the stock from rooted cuttings which have been taken from some plant already selected for its ability to root easily.

Mr. Tunstall said that he had been successful in getting cuttings to root by using Hortomone in the case of a bush from which he could not previously get cuttings to root.

TUNG.

The Chairman in referring to the next item on the Agenda—Tung—said that the Department had issued a questionnaire to growers of Tung in North East India and as a result of that Questionnaire had some information on the subject which he would ask Dr. Wight to bring before the meeting.

The following points were then dealt with—

(1) Two mistakes were noted in the memorandum "Notes on Tung"—there are *four* species of Tung and not five as previously recorded and the technical description of the tung flower was in error. Mr. V. Narayanswami, Curator of the Herbarium, Royal Botanic Gardens, Calcutta, was to be thanked for his help in this matter.

(2) It seems pretty certain that *A. Montana* and not *Fordii* should be grown. The valuation of *A. Montana* oil is 90% that of *A Fordii* and the former species is a more successful tree and easier to grow, in Assam.

(3) The possibilities of Tung oil are not likely to be exhausted in a lifetime. It is used in the aircraft industry, and some 400 tons are imported into India yearly—against 3-4 tons annual internal production.

(4) Most people who have grown Tung agree that a certain amount of research is necessary if the industry is to be a success.

(5) The chief problem to be tackled is selection for uniformity and there seems much more hope of making a rapid improvement than in tea.

(6) If the exclusive growing of *A. Montana* is decided upon, the need for a Tung research station will not be so great, but will still be very desirable.

(7) A great deal of useful information is now in the possession of different concerns growing Tung, which if it was all correlated by some independent person would mean a definite step forward for everybody. The present attitude is to tell the other man as little as possible. Furthermore, interested parties are out of touch one with the others. It seems that before we can go any further Tung growers must get together in a spirit of co-operation and a Tung Growers Association

seems to be indicated whose first duty would be the collection and tabulation of all the available information ; this could be submitted to some competent Agricultural Institution for examination. The Tung Growers could find men amongst themselves capable of doing this work which would yield results of immediate value. People however seem much keener on shouting for a research station—the next step will be to grumble at the cost and then one finally blames the men in the station for one's own inability to help oneself to the results of research.

Mr. Tunstall referred to disease affecting the collar of Tung tree and ascribed this to the effect of waterlogging of the soil round the collar. Frequently the plants were grown among jungle and the weeds were cleared from round the collar of the plants by forking. This often left a depression in which water collected, thus causing local waterlogging of the soil.

Dr. Wight said that the Tung tree required well aerated soil and that many roots of Tung examined showed that the tree was suffering from lack of soil aeration. Tung certainly grows best in a light soil.

The Chairman mentioned that the variety *A. Montana* was indigenous to the Shan Hills and it was reasonable to expect that it would grow better in Assam than the variety *A. Fordii*, which was not indigenous in a locality of similar climate to that of Assam.

It was realised that there might be a need for a second crop in the tea industry and the growing of Tung held out big possibilities. It was a mistake to work on haphazard methods. All available information should be pooled. The suggestions he had to make were (1) that a Tung Growers' Association should be formed, (2) that a systematic research scheme should be inaugurated. Such a scheme had already been devised by Dr. Wight and himself and was as follows.

A three years intensive programme to determine the practical value of the work. At the end of the third year the results to be examined by a competent committee and the initial temporary station either closed down or established on a permanent basis with a long term programme.

The idea is to go all out for the information required within three years and then decide whether to establish a station or not.

Having decided upon the programme it will be essential to completely staff and equip the temporary station with everything necessary to make the proposed investigations in the most expeditious and efficient manner. If the man in charge of the station is to prove his value in three years it is no use adopting a "wait and see" policy whose slogan is "let us see what is going to come out of the investigation before we give the man suitable apparatus to get on with the job quickly". It is unfair to ask any man to make his work a commercial proposition under these conditions. The only limiting factor to a venture such as we are at present discussing must be the scope of the investigation.

Staff should be employed for three years only. If good apparatus is bought there should be no difficulty in disposing of it for at least half price in Calcutta after three years. The working details of the scheme were not referred to. The inclusive cost of the whole scheme for 3 years was given as Rs. 30,000/- which was stated to be a relatively small sum when spread over 3 years and distributed amongst the parties interested.

MISCELLANEOUS.

Mr. Tunstall referred to the problem of Eelworm in soils. He said that while he was in England in 1937 Prof. Goody had told him that there was little hope in the near future of finding a cure for this pest. Under these circumstances it would seem that it was better to avoid soils likely to be contaminated by eelworm when choosing sites for nurseries.

The Chairman brought up the subject of having one day in each week specially set apart for visitors coming to Tocklai. He did not want the impression to be obtained that Tocklai discouraged visitors, on the contrary they wanted to make visitors even more welcome, but he wished to have things systematised in this connection. He said that this mainly affected people in Assam who often call in at Tocklai when passing through. Provided notice was given of intended visits, as was generally the case with visitors from the more distant tea districts, arrangements could be made to show them round on any day of the week.

Mr. McLennan said that all districts in Assam had been circularised regarding the proposal to set aside Wednesday in each week as "Visitors Day" at Tocklai.

The Chairman mentioned the subject of the growing of Cinchona in tea districts of North East India. He said that the Government of India had deputed a Cinchona Enquiry Committee headed by Mr. Wilson to tour India and to find places which might prove suitable for the growing of Cinchona. Sir John Russell had suggested that a visit might be paid to Assam by the Cinchona Committee.

Mr. Smart said that he had had the following enquiry from one of the Surma Valley Districts :—

"What are the methods at present advised for the prevention of Black rot and Red spider ?"

The Chairman outlined the method advised by the Department for controlling Black rot and made it clear that the method, consisting of spraying affected bushes in the growing season with 1% Burgundy Mixture, controlled the disease but did

not necessarily eliminate it. He said that the methods for controlling Red spider were clean pruning, and spraying with Lime sulphur solution in the spring at the first sign of attack.

The treatment of Red spider by defoliation was referred to, and the Chairman said that defoliation certainly reduced Red spider attack. This had been demonstrated at Borbhetta in 1937. In the case of bushes low in reserves, e. g. weak or young plants, defoliation would do more harm than good.

The Chairman pointed out that the aim and object of the Conference was to enable delegates to discuss the work of the Department and to consider criticisms and suggestions in connection with future work. In the case of enquiries such as those on treatment of disease, etc., the garden or district concerned should refer to Tocklai, who would issue a memorandum dealing with the subject.

Mr. Harrison stated that all the available information on Red spider and its treatment had been collected and could be issued immediately in the form of a bulletin.

Mr. Smart asked whether it was advisable in the case of a garden which had not been manured for years to send its soils for analysis before commencing a manuring programme.

The Chairman said that a complete analysis was not required but that it would be advisable to send soil samples to Tocklai for acidity determinations.

The Chairman stated that regular touring of the tea districts by the Scientific Officers would be resumed in 1938. after a lapse of 5 years. The following were the touring arrangements for 1938 :—

Month.	District.	Touring Officer.
January	Dooars and Terai Branches Annual meetings.	Mr. Benton
February	Cachar (Surma Valley Branch I. T. A. meeting)	Mr Cooper
,,	Doom Dooma	Dr. Wight
March	Tezpur and Bishnath	Mr. Harrison
,,	Darjeeling and Terai	Dr Wight
April	Eastern Dooars and Dalgaon District	Mr. Harrison
May	Dibrugarh and Panitola	Mr. Cooper
July	Balisera, Luskerpore North Sylhet	Mr. Harrison
August	Western Dooars	Mr. Cooper
September	Lakhipur and Happy Valley	Mr Harrison

The Chairman announced that, as there was no further business before the Conference he would ask Mr. E. J. Nicholls to say a few word in conclusion.

Mr. Nicholls spoke as follows :—"On behalf of the visitors I wish to express our full appreciation and thanks to Mr. Carpenter and the Officers of the Scientific Department for all that they have done in making the Conference so interesting. Each one of us must have benefitted by the excellent addresses we have heard and from the discussions which have taken place. We feel sure that the results of this Conference will be to the ultimate advantage of the industry as a whole.

There is no better way of overcoming our difficulties than for Scientific Officers and the senior practical men to meet across the table to discuss the needs of the industry and I do feel that during these three days much good work has been accomplished."

R. P. W.–1,150–6-38.